



## AMS Tracker Thermal Control Subsystem TTCB and condenser integration welding into TTCS-loops

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**2.0**  
**AUGUST 2007**

Sun Yat-Sen University (SYSU)  
National Aerospace Laboratory (NLR)  
Istituto Nazionale di Fisica Nucleare (INFN)

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| <u>Change Ref.</u> | <u>Section(s)</u> | <u>Issue 1.0</u>         |
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| -                  | All               | Initial issue            |
| <u>Change Ref.</u> | <u>Section(s)</u> | <u>Issue 2.0</u>         |
|                    | Section 3.4       | Type update              |
|                    | Section 4.3       | Weld samples update      |
|                    | Section 7.2       | Weld equipment additions |
|                    | Appendix M        | Added Weld head specs    |



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## 1 Scope of the document

The procedure in this document describes the weld procedure for

- welding the additional hydraulic connectors needed to attach the mini-TTCS during beam testing
- welding the hydraulic end connectors used for closing the system. This document does NOT concern welds the hydraulic connectors connected to the evaporator. These welds are described in RD-2.
- Welding the TTCB on-site in the AMS02 Clean room in CERN to the TTCS transport tubes

It contains the following steps:

- Weld qualification
  - Identification of optimum weld parameters  
(copy of the weld parameters from previous connector and tube welds)
  - Weld qualification
- Weld re-qualification (if necessary)
- Flight Weld steps
  - Pre-welds
  - Flight welding
  - Post-weld

The objective is to verify the hydraulic connector welds will fulfil the NASA weld requirements and meanwhile provide the safety verification documentation.

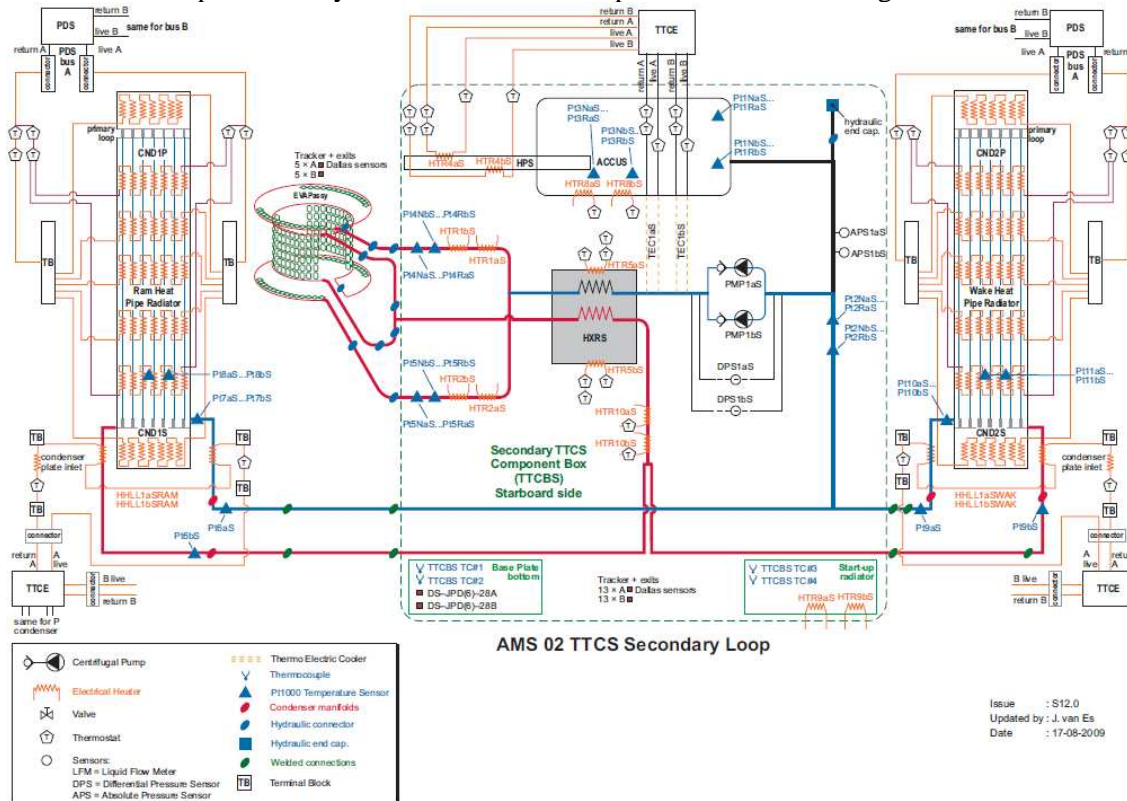
## 2 References documents

|      | Title  | Number                    | Date       |
|------|--|---------------------------|------------|
| RD-1 | TTCS Requirements<br>Verification Matrix FM H/W  | AMSTR-NLR-PL-02 Issue 1.0 | April 2007 |
| RD-2 | REQUIREMENTS FOR THE<br>MANUFACTURING AND SPACE<br>QUALIFICATION OF ALL THE<br>PRESSURIZED WELD JOINTS IN THE AMS<br>TTCS EVAPORATOR | ASR-S-001 Rev B           | Sept 2003  |

### 3 Identification of welds

#### 3.1 Weld locations of additional hydraulic couplings

In the TTCS loop the new hydraulic connectors are present at the following locations:

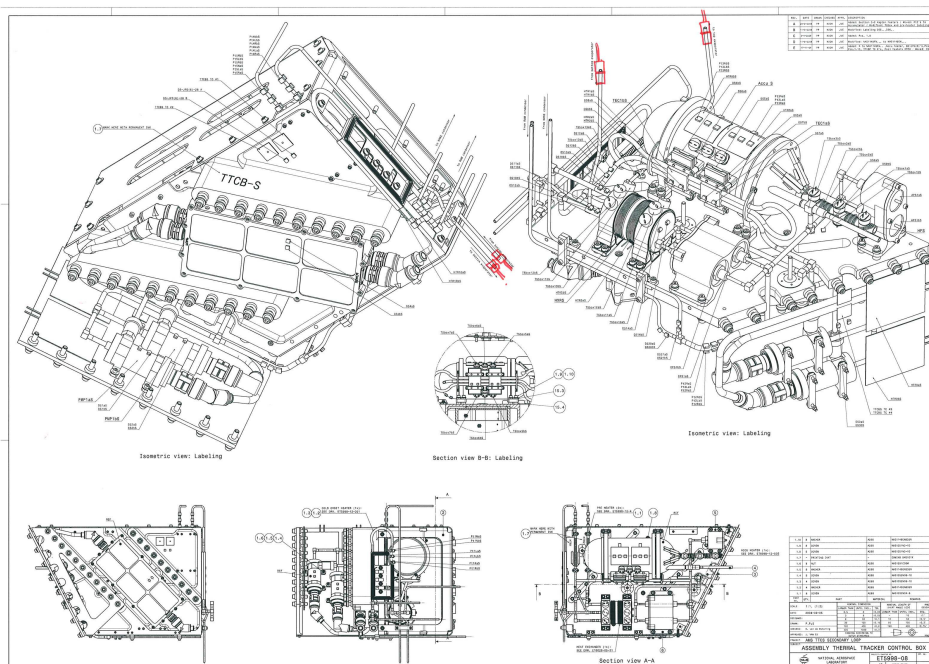


**Figure 3-1: TTCS loop Schematic Secondary Loop**

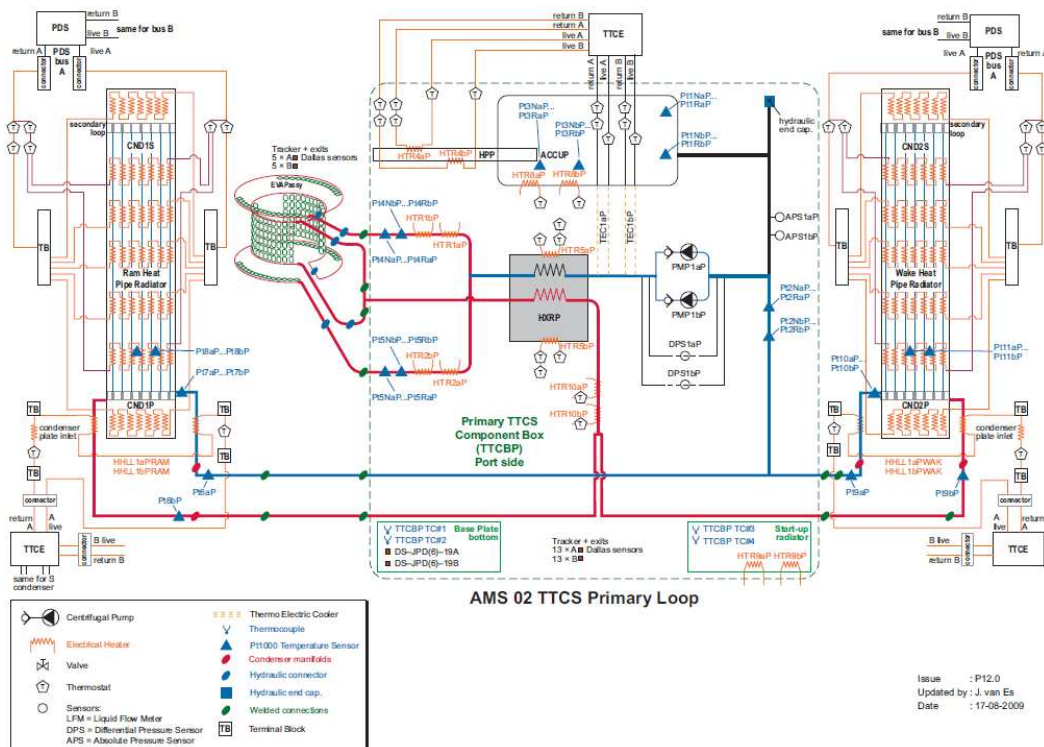
The secondary loop contains:

- 4 additional hydraulic connectors for the connection to the mini-TTCS
- 1 hydraulic connector for re-filling
- 1 hydraulic end cap

The location of the hydraulic connectors is shown in below assembly drawing:

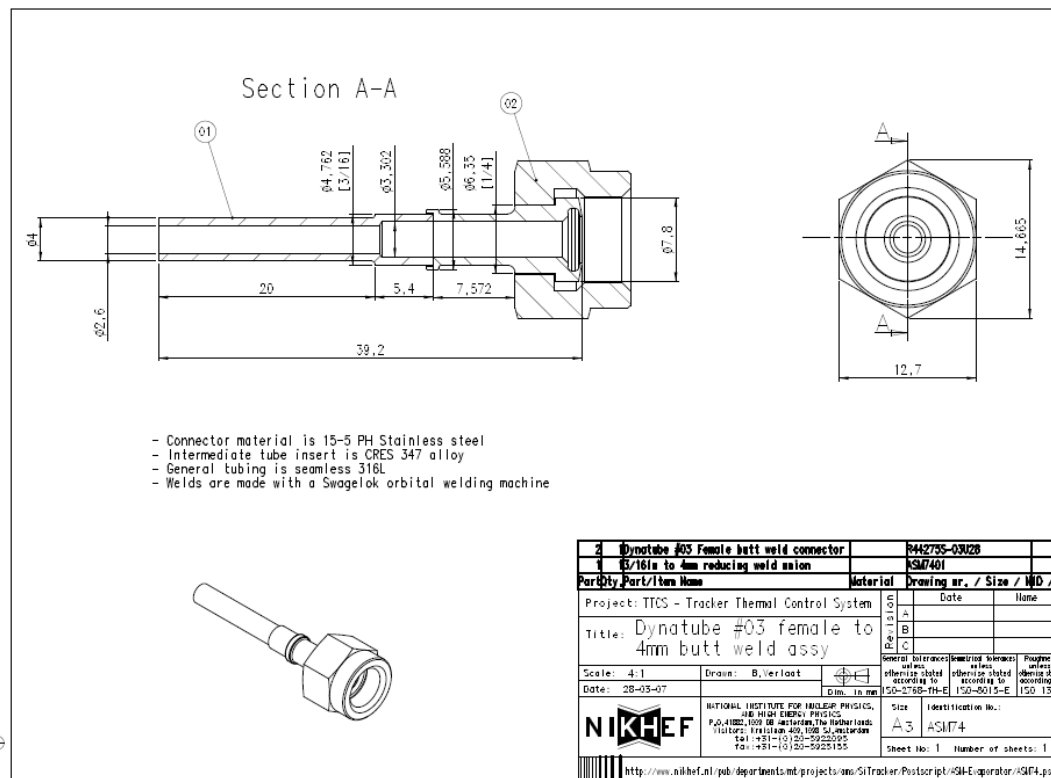


**Figur 3-2: TTCB-S connector locations (to be updated soon)**



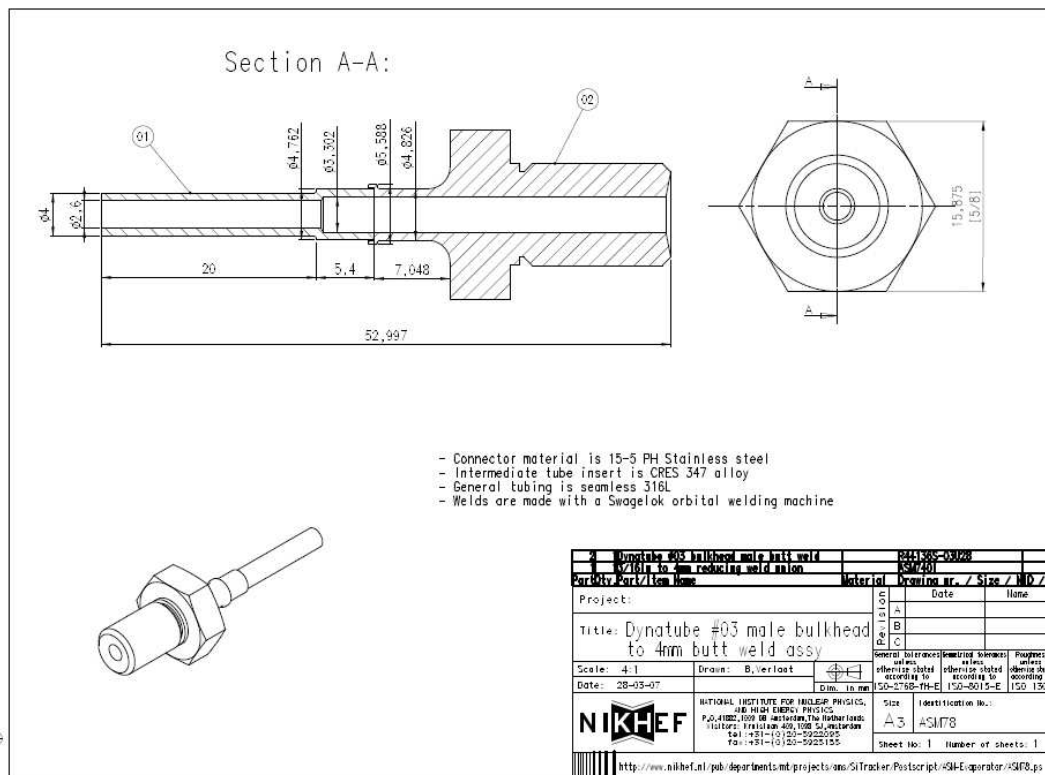
**Figur 3-3: TTCS loop Schematic Primary Loop**

The primary loop only contains one hydraulic end cap.



**Figuur 3-4: Parker Hydraulic connector R44275S-03U28 with intermediate tube**

The R44275S-03U28 Parker hydraulic connector (Material: PEP 15-5 PH) is connected to the TTCS transport tubes (316L) by a small tube segment with an intermediate material (CRES 347). The same construction is used for the mating coupling R44276S-03U28 as shown in Figuur 3-5.

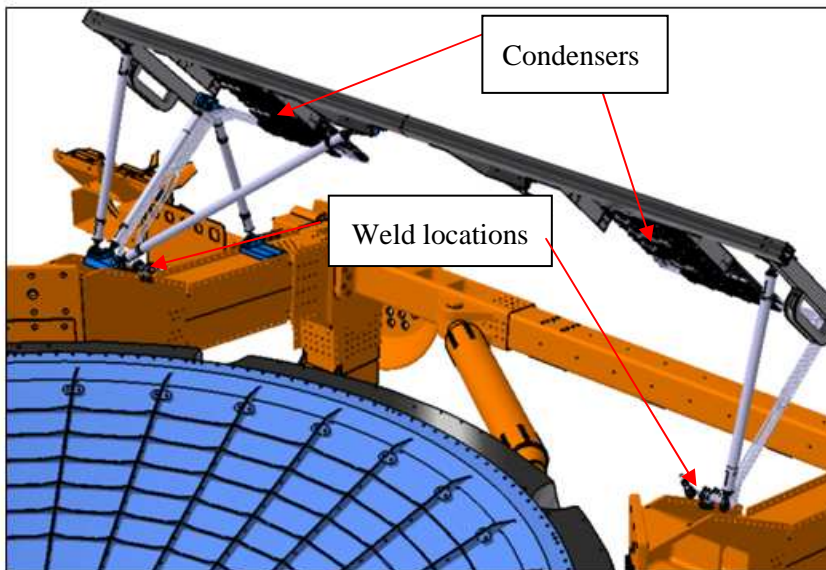


**Figuur 3-5: Parker Hydraulic connector R44276S-03U28 with intermediate tube**

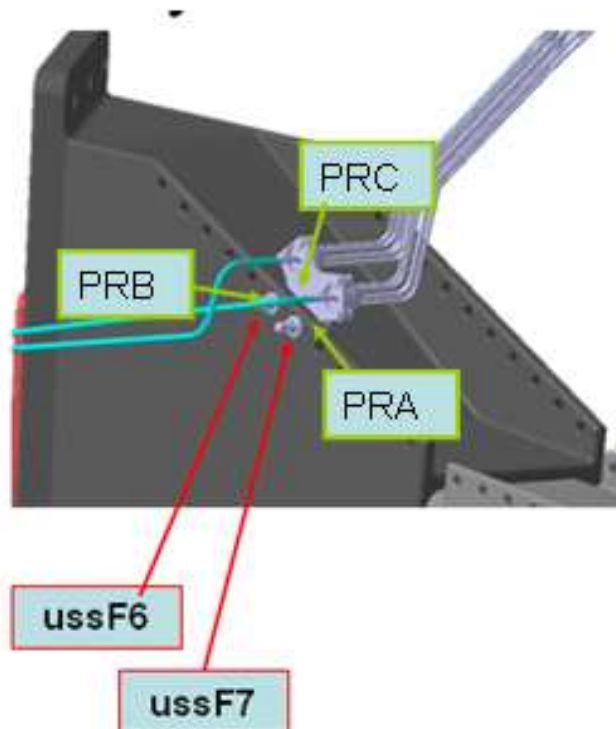
For the end caps used at the fill ports also R44276S-03U28 couplings are used. However these are connected to 6 mm 316L tubes which leads to some a different intermediate tube (CRES 347). In Appendix A intermediate tubes are shown.

### 3.2 Condenser inlet and outlet weld locations

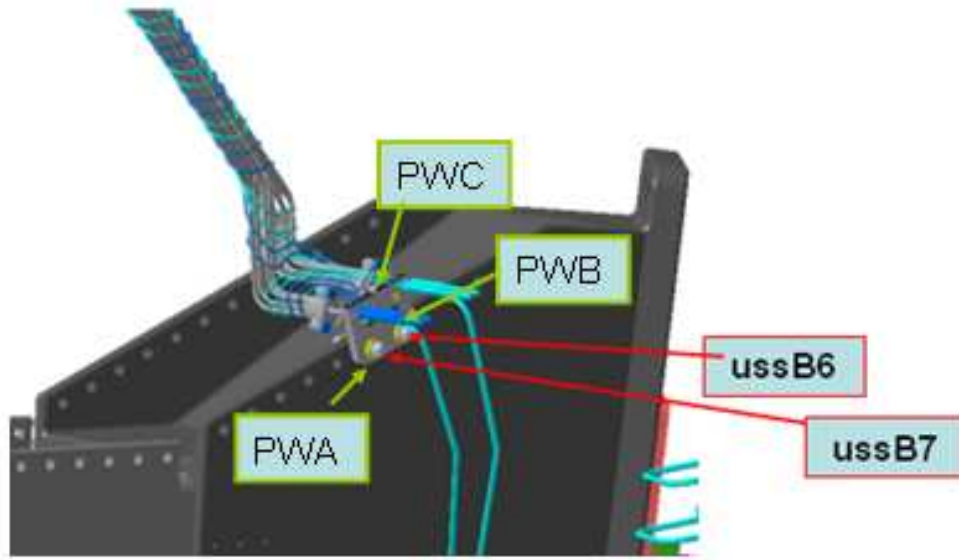
After condenser integration the transport tubes need to be welded to the condenser inlet and outlets. The TTCS has 4 condenser leadin a total of 8 online welds. Two condensers are located on RAM side and two on Wake side the mechanical lay-out is shown in below figures. The condenser welds are all of type V in Table 4-2.



**Figuur 3-6: Condenser locations**



**Figuur 3-7: Manifold inlet location details**

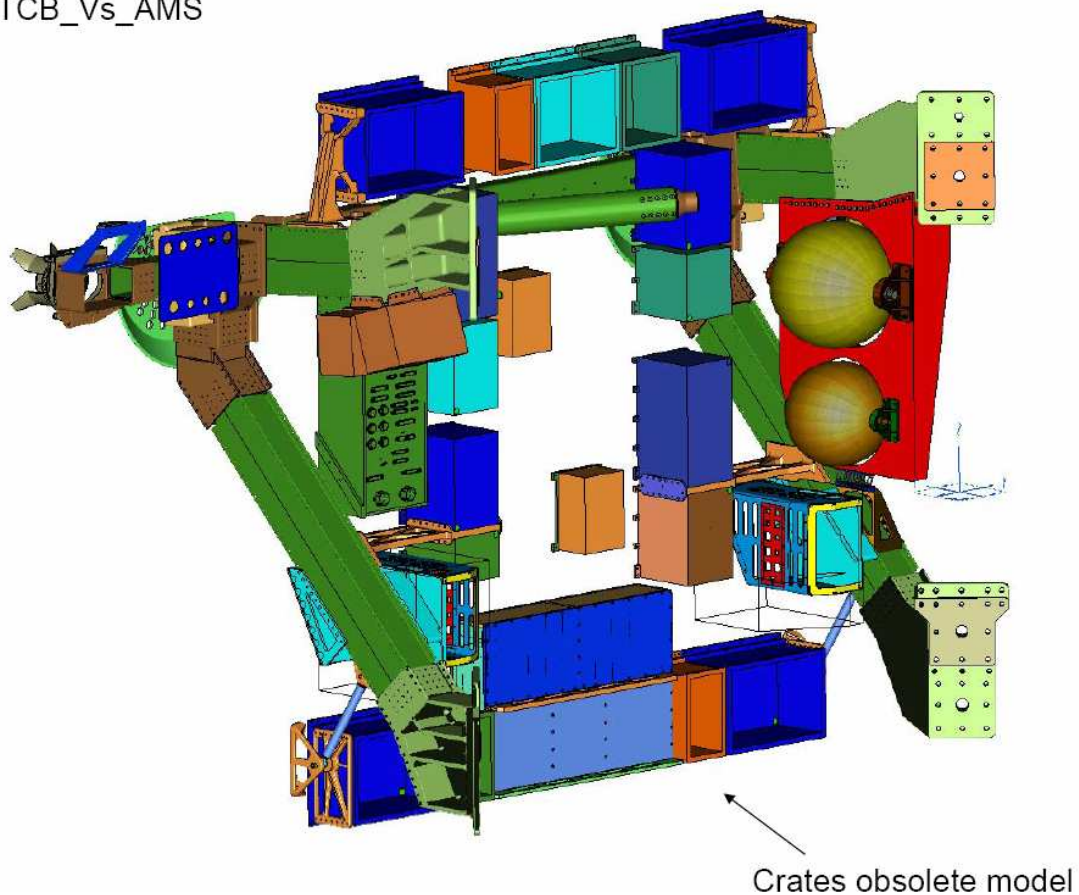


**Figuur 3-8: Manifold inlet location details**

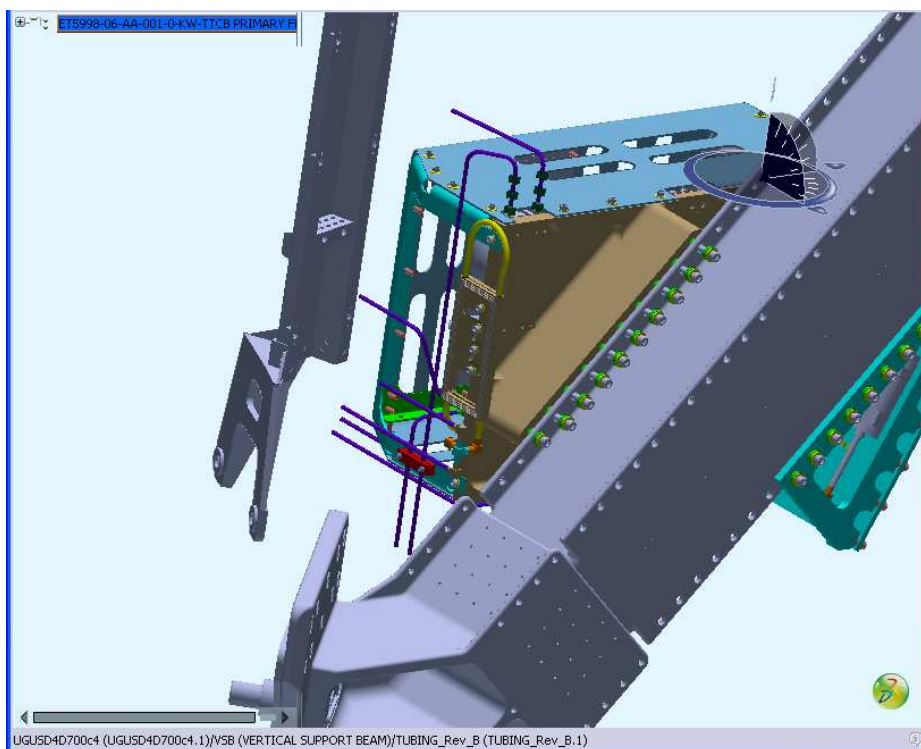
### 3.3 TTCB connections weld locations

The TTCB's are located on the USS as shown in Figuur 3-12. The TTCB-P is located on Port side the TTCB-S on Starboard side.

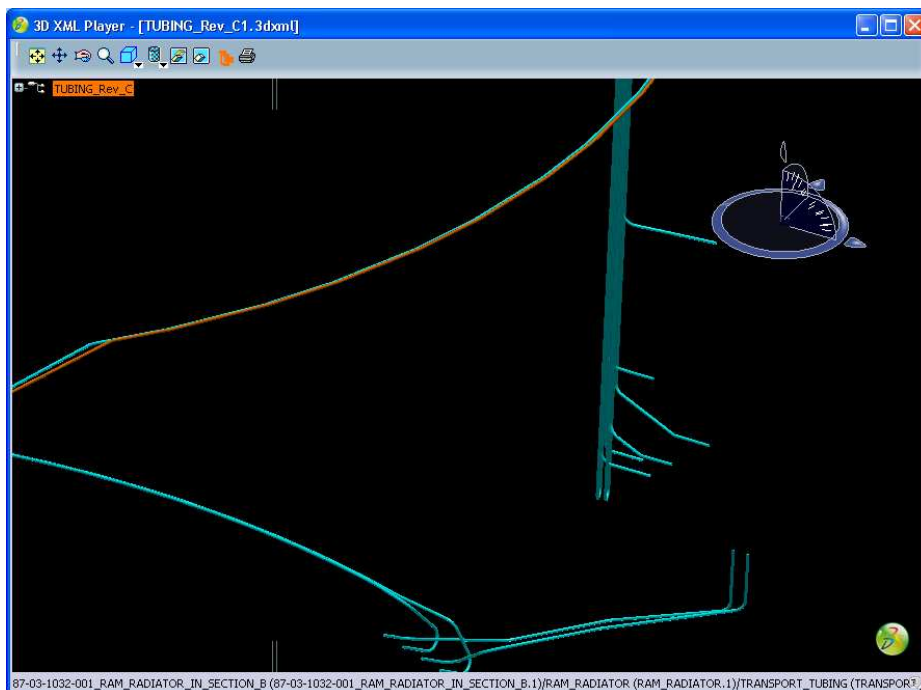
TTCB\_Vs\_AMS



**Figuur 3-9: TTCB locations on AMS**



**Figuur 3-10: TTCB weld locations on AMS**



**Figuur 3-11: TTCB tube routing AMS**

### 3.3.1 TTCB-P welds

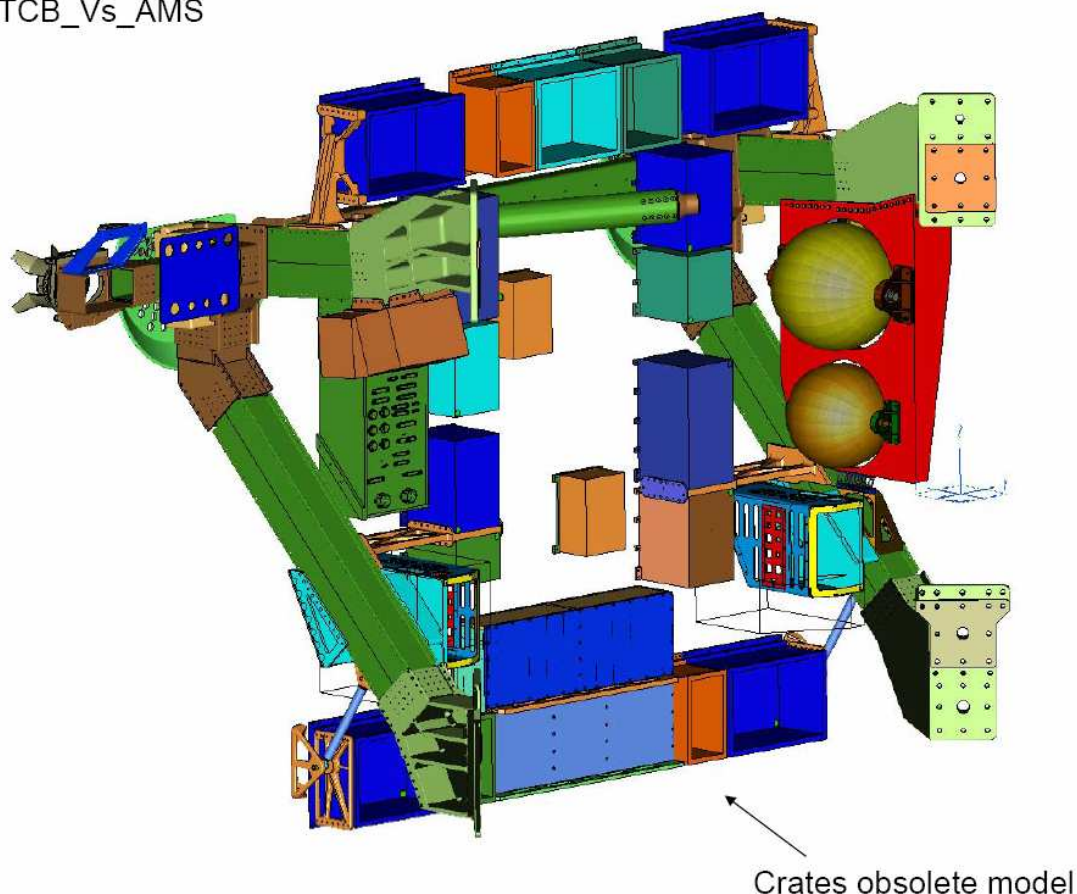
The TTCB-P will be completely welded into the TTCS-P tube system. This is a total of 8 welds. All welds are of the same type (Type IV in Table 4-2).

### 3.3.2 TTCB-S welds

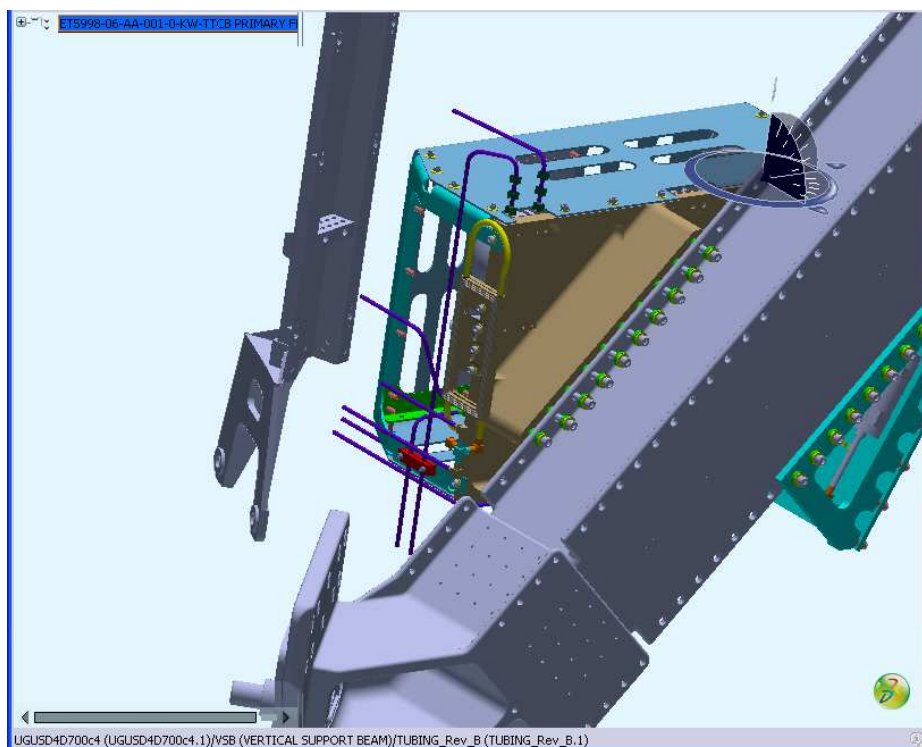
The connection to the TTCB evaporators is via connectors. The connectors on the box side (see Figure 3-2) are welded off-line (type III in Table 4-2). The connectors on the transport tube side are welded on-line (Type IV in Table 4-2).

The TTCB-S has 4 TTCB condenser inlet and outlet connections will also be welded (Type IV in Table 4-2) online.

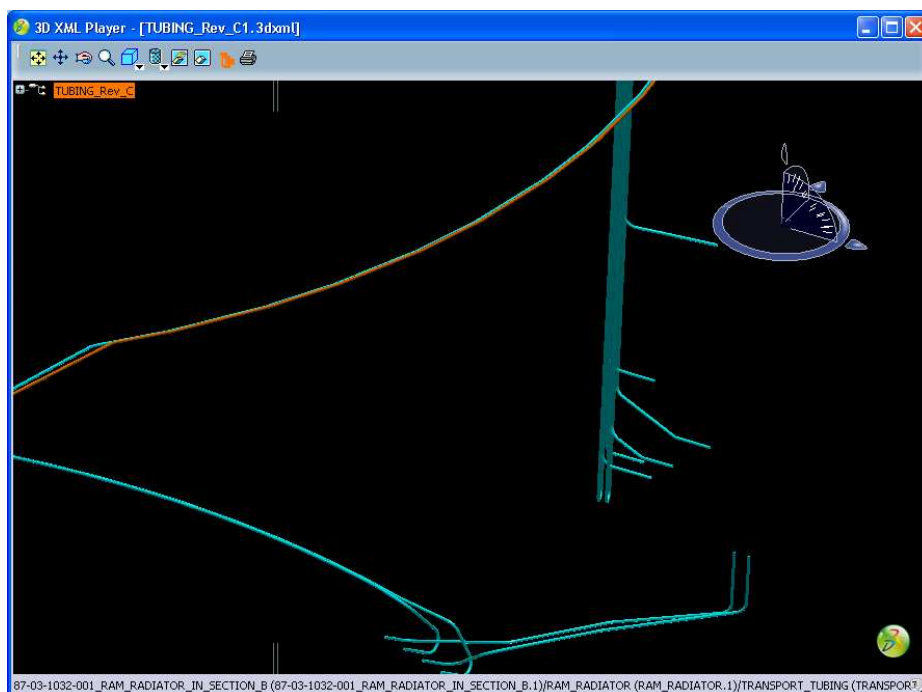
TTCB\_Vs\_AMS



**Figuur 3-12: TTCB locations on AMS**



**Figuur 3-13: TTCB weld locations on AMS**



**Figuur 3-14: TTCB tube routing AMS**



### 3.4 Weld types identification

The welding of the hydraulic connectors to the transport tubes includes the following types of welds:

#### 5.6 mm trumpet weld (all hydraulic connectors)

- Hydraulic connectors (R44276S-03U28 and R44275S-03U28) to intermediate CRES 347 tube sections

#### 4 mm welds (mini-TTCS couplings)

- 4 mm standard tube stainless steel 316 L to 4 mm CRES 347 intermediate tube section
- 4 mm standard tube to 4 mm standard tube (both Microgroup batch)  
Connection to TTCS transport tubes
- 4 mm standard tube 316L (NIKHEF batch) to 4 mm standard tube 316L (Microgroup batch)  
Connection to TTCS's
- 4 mm standard tube 316L (Microgroup batch) to 4 mm 316L condenser manifolds  
Connection to condensers

#### 6 mm welds (end coupling)

- 6 mm standard tube stainless steel 316 L to 6 mm CRES 347 intermediate tube section
- 6 mm standard tube 316 L to Swagelok weld coupling
- 6 mm standard tube 316 L to standard tube 316L

For each combination of materials a weld qualification is needed. The welds from different material batches are considered to be a different material and require additional qualification.

### 3.5 Class identification

All welds are classified as class B according to NASA document PRC0010. TTCS is a pressurised system and therefore class B requirements and methods for pressurised components are applicable.

## 4 Weld qualification

A weld qualification consists of the following steps:

- Identification of optimum weld parameters
- Weld qualification

The weld qualification is performed on a total of 9 weld samples.

| Weld settings                  | Number of welds | Examination                   |
|--------------------------------|-----------------|-------------------------------|
| Limit high heat input settings | 3               | 1 cut sample (see Figure 4-1) |
|                                |                 | 2 normal samples              |
| Limit low heat input settings  | 3               | 1 cut sample (see Figure 4-1) |
|                                |                 | 2 normal samples              |
| Nominal heat input settings    | 3               | 1 burst sample                |
|                                |                 | 2 normal samples              |
| <b>Total</b>                   | <b>9</b>        |                               |

**Table 4-1: Qualification samples quantity overview**

All samples shall be send to NASA (TBC) where they will be subjected to:

- Visually inspection to the Class B acceptance criterias in Appendix G.
- Liquid penetrant or magnetic particle inspection to the Class B acceptance criterias in Appendix G.

One sample of high heat and one of the low input input settings shall be cut as shown below as



**Figure 4-1: Longitudinal cut sample examples**

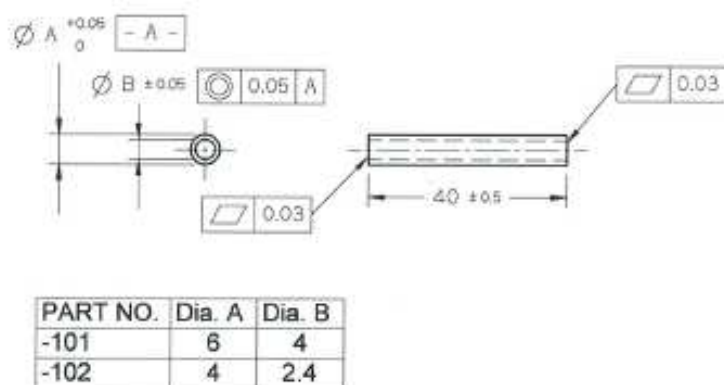
shown in Figure 4-1 to check the class B criteria in Appendix G focussed on through welding. One of the samples with nominal heat input settings shall be subjected to a burst test. The burst testing shall be done according to the test procedure requirements in Appendix J.

#### 4.1 High and low heat input settings

The aim of the range of input settings shall be in the order of  $\pm 10\%$ , but this is no hard requirement. The flight hardware welds shall be made with the nominal power setting. In this case the flight welds are qualified for power fluctuations in the welding apparatus between the low and high limits.

#### 4.2 Standard Weld samples

The weld samples shall be cut in the same way as the flight hardware. A drawing of the weld samples is shown in Figure 4-2. Design drawings of all weld samples types are shown in Appendix H and I.



**Figure 4-2: Weld sample example**

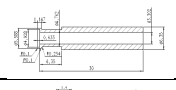

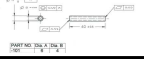
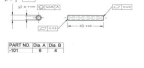

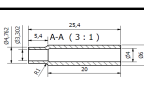
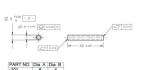

### 4.3 Qualifications summary

In the following table the required samples are summarised.

| DIAMETER | TYPE Orbital Welding  | Picture | QUALIFICATION | RE-QUAL |
|----------|---|---------|---------------|---------|
| 5.6      | Type I Hydraulic connector material to CRES347 5.6 mm OD      | N/A     | 9             | 3       |
| 4        | Type II CRES 347 to 316L 4mm OD (Microgroup batch)            | N/A     | 9             | 3       |
| 4        | Type III 316L (Microgroup batch) -316L (Microgroup batch)     | N/A     | 9             | 3       |
| 4        | Type IV 316L (NIKHEF batch) -316L (Microgroup batch)          | N/A     | 9             | 3       |
| 4        | Type V 316L 6mm (Microgroup batch) to 316L Condenser manifold | N/A     | 9             | 3       |
| 6        | Type VI CRES 347 to 316L 6mm OD                               | N/A     | 9             | 3       |
| 6        | Type VII 316L 6 mm OD to swagelok weld coupling               | N/A     | 9             | 3       |
| 6        | Type VIII 316L to 316L 6mm OD standard                        | N/A     | 9             | 3       |

**Table 4-2: Summary of qualification samples**

The inventory of the sample parts is shown in Table 4-3.

| DIAMETER | SAMPLE TYPE  | Picture   | # PARTS REQUIRED             | #STOCK |
|----------|--|---|------------------------------|--------|
| 5.6      | Hydraulic connector material (15-5 PH) samples       |   | 23<br>(Q/F/P&P)<br>(9/8/6)   | 30     |
| 4        | CRES 347 intermediate connectors 4 mm                |   | 32<br>(Q/F/P&P)<br>(18/8/6)  | 50     |
| 4        | 4mm OD tube (NIKHEF batch) 316L                      |  | 15<br>(Q/F/P&P)<br>(9/0/6)   | >10 m  |
| 4        | 4mm OD tube (Microgroup batch) 316L                  |  | 56<br>(Q/F/P&P)<br>(36/8/12) | 6 m    |
| 4        | 4mm OD machined tube 316L (condenser manifold batch) |  | 15<br>(Q/F/P&P)<br>(9/0/6)   | 30     |
| 6        | CRES 347 intermediate connector 6 mm                 |  | 19<br>(Q/F/P&P)<br>(9/4/6)   | 30     |
| 6        | 6mm OD tube 316 L                                    |  | 39<br>(Q/F/P&P)<br>(27/0/12) | 6 m    |
| 6        | 6 mm OD 6LV-6MMW-9 swagelok weld coupling 316 L      |  | 17<br>(Q/F/P&P)<br>(9/2/6)   | 30     |

**Table 4-3: Sample inventory**



## 5 Welding procedure specification (WPS)

Process verification shall consist of visual inspection and/or (non)-destructive inspection, as described further in section 4 for weld qualification and section 6 for re-qualification. In addition, at the appropriate time during the fabrication activities, the following items shall be verified:

- Verify that the welder is certified for the specific welding operation (prior to welding).
- Fit-up in accordance with the engineering drawing (prior to welding for Class A Pressure Containing Components).
- A WPS exists (prior to welding) see section 5.1.
- Compliance with WPS for essential variable ranges (during welding).

### 5.1 Welding procedure specification (WPS)

The welding process shall be documented in a Welding procedure specification (WPS). The WPS shall be reviewed by NASA before the production of the actual flight and qualification H/W. An example WPS as will be used for TTCB welding is shown in Appendix K.

### 5.2 Welding Procedure Qualification Record (PQR)

Welding results (all qualification, re-qualification, post and pre-weld sampled) shall be documented in a Procedure Qualification Record (PQR). An example PQR as will be used during flight qualification and flight welding is given in Appendix K.



## 6 Weld re-qualification

Re-qualification of welds will be performed in the following cases:

- The weld system has been placed on a different external power source except when the power supply has a means for internal power regulation,
- Major maintenance has been performed on the weld system. Major maintenance includes replacement of the power supply, major repair of the power supply requiring entrance into the controller or transformer cabinet, replacement of the weld head, or replacement or change in length of any of the interconnecting cables.

A re-qualification exists of the following steps:

- Weld re-qualification

| Weld settings                  | Number of welds | Examination                         |
|--------------------------------|-----------------|-------------------------------------|
| Limit high heat input settings | 1               | Visual Inspection<br>Volumetric NDE |
| Limit low heat input settings  | 1               | Visual Inspection<br>Volumetric NDE |
| Nominal heat input settings    | 1               | Visual Inspection<br>Volumetric NDE |
| <b>Total</b>                   | <b>3</b>        |                                     |

**Table 6-1: Qualification samples quantity overview**

Re-qualification requires only 3 samples with settings and sequence as shown above. The samples are subjected to visual inspection and volumetric NDE. The re-qualification results will be send electronically to NASA and to NLR for approval.

If the requalification activities result in any welding parameter(s) deviations that exceed the range specified in Table V of PRC0010 or AWS B2.1 as applicable, for that parameter, then the level of testing in section 4 is required. Table V is copied below.

Table V - Essential Welding Variables

| Variable # | Variable / Weld Type                          | Range Allowed |
|------------|---|---------------|
| 1          | Power Source Model #                          | None          |
| 2          | Weld Head Model #                             | None          |
| 3          | Joint Configuration                           | None          |
| 4          | Groove Angle                                  | +/- 5°        |
| 5          | Nominal Tube Dia.                             | None          |
| 6          | Nominal Wall Thickness                        | None          |
| 7          | Material Type(s)                              | None          |
| 8          | Electrode Start Position                      | +/- 60°       |
| 9          | Preweld Cleaning Steps                        | None          |
| 10         | Allowable Joint Gap                           | None          |
| 11         | Tool or Shop Aid Identification               | None          |
| 12         | Preweld Purge Time                            | (1)           |
| 13         | Postweld Purge Time                           | (1)           |
| 14         | Tube ID Prepurge Flow Rate or Pressure        | None          |
| 15         | Weld Head Prepurge Flow Rate                  | +/- 15%       |
| 16         | Plasma Gas Flow Rate                          | +/- 10%       |
| 17         | Gas Composition/Spec.                         | None          |
| 18         | Electrode Travel Speed & Machine Setting      | None          |
| 19         | Arc Travel Start Delay                        | None          |
| 20         | Total Weld Current On Time                    | None          |
| 21         | Weld Time @ Level or Circumference Interval   | None          |
| 22         | Current Pulse Width (%)                       | None          |
| 23         | Current Pulse Rate                            | None          |
| 24         | Filler Material / Spec.                       | None          |
| 25         | Filler Wire Feed Speed                        | +/- 50%       |
| 26         | Consumable Insert Type and Specification      | None          |
| 27         | Tubular Sleeve Spec.                          | None          |
| 28         | Background Welding Current                    | None          |
| 29         | Pulse Welding Current                         | None          |
| 30         | Electrode Type                                | None          |
| 31         | Electrode Diameter                            | None          |
| 32         | Electrode Tip Geometry                        | None          |
| 33         | GTAW Electrode to Work Gap (nom. setting)     | +/- 10%       |
| 34         | PAW Electrode Position Setting (nom. setting) | +/- 10%       |
| 35         | PAW Orifice Size                              | None          |
| 36         | Minimum Preheat Temp.                         | None          |
| 37         | Maximum Interpass Temp.                       | None          |
| 38         | PWHT Procedure/Spec.                          | None          |

**Tabel 6-2: Essential welding variables**



## 7 Flight Welding

For welding of the hydraulic connectors tube welding with flow-through shielding gas is used. The detailed integration weld sequence is described in section XX.

### 7.1 Tube welding preparations

#### 7.1.1 Cleaning and clean working

The welding and welding preparation of the tubing and components will be performed in a class 100,000 or better clean room environment. The flight tubes and flight weld samples are clean inside. Handling is focussed in avoiding contamination to get inside and keep the tubes clean. For cleaning on the outside Iso-Propyl-Alcohol (IPA) will be used as it leaves no residue on the tubes. Details of the cleaning are described in the TTCS Box bending procedure AMSTR-AIDC-PR-020.

#### 7.1.2 Tube cutting

Tube cutting will be done according to the tube cutting procedure AMSTR-SYSU-PR-008. Cutting will be done while filtered clean gas is flown through the tube. Special to the tube cutting is to take into account (add) the tube shrinkage during welding. Before cutting need to add the welding shrink dimension. This dimension was tested.

#### 7.1.3 Pre-weld and post-weld samples

In order to assure the weld quality during the complete TTCS integration process each day:

- two pre-weld samples (for each weld type performed that day)
- one post-weld samples (for each weld type performed that day)

The pre- and post-welds are made according to the WPS and examined and documented in a PQR by NIKHEF. At the end of each day the filled procedures and PQR's are send to the NASA weld specialist and the TTCS project leader for review.

#### Pre-production anomalies

In case pre-production weld samples do not meet requirements and no assignable cause for the failure can be determined the welding activities will be stopped at once. The TTCS project leader at NLR, and the NASA weld specialist shall be contacted as soon as possible to discuss how to proceed.

In order to reduce the number of pre- and post-welds as much as possible the same weld types are planned on one day.

## 7.2 Weld equipment



**Figuur 7-1: Swagelok welding system**

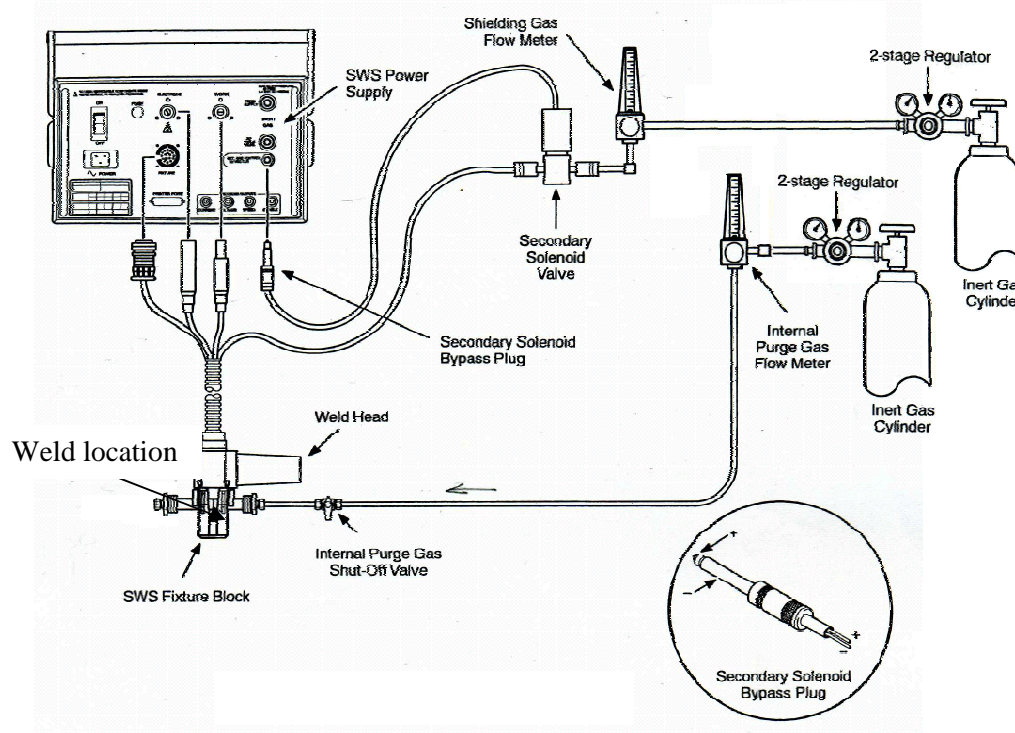
The orbital welds will be made with a Swagelok/Cajon™ M100 orbital welding system. The system includes the following hardware:

- Welding head: Cajon™ CWS-5H-B
- Fixture block: Cajon™ CWS-5TFB
- Collets: Cajon™ CWS-5UCI-04mm

The on-line welding will be done with a micro weldhead series 4 as shown in Appendix M. Fixtures are available for 4 mm and 6 mm tubes

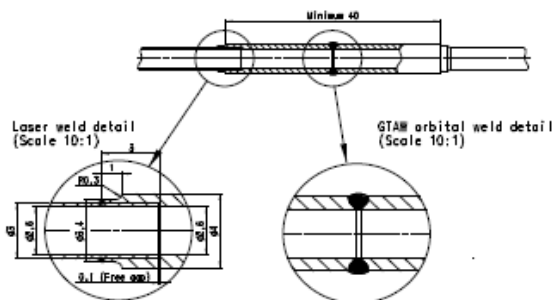
### 7.3 Standard tube orbital welding with flow-through shielding gas

The standard tube orbital weld method is used for most of the TTCB welds. The purge gas set-up is shown in Figure 7-2.



**Figure 7-2: Purge gas set-up flow through**

In Figure 7-3 you find a typical weld sample.



**Figure 7-3: Drawing of a tube weld connection concept**



### 7.3.1 Main steps for welding with flow-through shielding gas

The main steps are:

1. Perform pre-weld test samples according to the applicable WPS in Appendix L.
  - a. Use fixture to fix tube in line
  - b. Spot weld tubes together (specify spot weld) and document weld parameters
  - c. Purge gas with DP gage before welding
  - d. Perform welding
2. Document the weld parameters in PQR as in Appendix K.
3. NDE Examination of weld samples
  - a. If samples fulfil requirements
    - i. Document the weld sample examination results
    - ii. Proceed with flight welding preparations
  - b. If samples do not fulfil requirements
    - i. Find out cause of anomaly and report to TTCS PM
    - ii. If anomaly is well understood start with step 1 and continue
    - iii. If anomaly is not understood stop welding and contact TTCS PM and NASA weld specialist at once to discuss how to proceed.
4. Flight weld preparations
  - a. Document part numbers
  - b. Check material traceability and certificates
5. Perform flight welding
  - a. Use fixture to fix tube in line and/or components
  - b. Take picture of weld set-up
  - c. Purge gas with DP gage before welding
  - d. Perform welding
6. Direct after last weld of the same weld type perform post-weld sample
  - a. Use fixture to fix tube in line
  - b. Purge gas with DP gage before welding
  - c. Perform welding
7. NDE Examination of post-weld sample
  - a. If sample fulfils requirements
    - i. Document the weld sample examination results
    - ii. Continue with other weld type(s)
  - b. If sample does not fulfil requirements
    - i. Report to TTCS PM and to NASA weld specialist

## 8 TTCB and hydraulic connector weld sequence

The overall sequence of welding is as follows:

1. Off-line Connector weldings to CRES 347 and 316L (NIKHEF batch 4mm) @NIKHEF  
 (these are the mini TTCS connector welds for TTCB-S)
  - a. Pre welds
  - b. 8 welds CRES347 to 316L 4 mm
  - c. 8 welds CRES347 to connector 5.6 mm
  - d. Post welds
2. Off-line Connector weldings to CRES 347 and 316L (6mm Dockweiler) @NIKHEF  
 (this are the pinch tube welds for TTCB-P and TTCB-S)
  - a. Pre welds
  - b. 6 welds CRES347 to 316L (Dockweiler) 6 mm (including 1 spare pinch tube)
  - c. 6 welds CRES347 to connector 5.6 mm
  - d. Post welds
3. Condenser welds on AMS02 online @CERN
  - a. Pre welds
  - b. 8 welds 316 L (manifolds) to 316 L (Microgroup batch)
  - c. Post welds
4. TTCB's Fit check on AMS02 online
  - a. Check hydraulic connector locations (tooling access etc)
  - b. Check pinch locations
5. Off-line connectors welds to TTCB-S @CERN
  - a. Pre welds
  - b. 8 welds 316L (NIKHEF batch) to 316L (NIKHEF batch) 4 mm (to connect the connectors to TTCB-S)
6. Off-line connectors pinch inlet TTCB-S & TTCB-P @CERN
  - a. Pre welds
  - b. 2 welds Swagelok weld coupling to 316L (Dockweiler) 6 mm (with attached connector(s))
  - c. 2 welds Swagelok couplings to 316L (Dockweiler) (inlet TTCB) 6 mm  
 (TBC could also be online to better fit with the bracket)
  - d. Post welds



7. On-line welds TTCB-P

- a. Pre welds
- b. 8 welds 316 L (NIKHEF batch) to 316 L (Microgroup batch)
- c. Post welds

8. On-line welds TTCB-S

- a. Pre welds
- b. 4 welds 316 L (NIKHEF batch) to 316 L (Microgroup batch)
- c. Post welds

Green = @ NIKHEF

Yellow = off-line @ CERN

Red = on-line at AMS02 @ CERN

In the section 9 the purge set-up for the off-line and online connections to the TTCB's are shown. The TTCB fit checks are found in a separate ATS of on-line AMS02 activities.

## 9 Purge set-ups during welding

In below pictures the purge set-up are shown of:

- TTCB-S off-line welds
- TTC-P off-line welds
- Condensers welds online welds
- TTCB-P online welds
- TTCB-S online welds

The following general rules are applied.

- All welds will be performed as flow-through type welds
- Downstream the weld no (major) hydraulic resistance (e.g. pump) should be present  
(This would influence the back pressure measurement and so a different weld situation would be present than during flight and qualification)



## 9.1 TTCS-S off-line welds

Prior to making all the off-line welds the pump inlet tubes (from Wake condenser and from Ram condenser) are coupled via a T-branch and connected to the purge bottle.

All other openings are closed and opened in an alternating way. After this exercise the tubes will be mainly filled purge gas. The openings will be closed with kaptop tape.

**Figure 9-1: Purge inlet to fill the TTCB tubes before welding**

**Figure 9-2: Location of hydraulic connectors to be welded**

**Figure 9-3: Purge set-up top evaporator connection**

**Figure 9-4: Purge set-up bottom evaporator connection**



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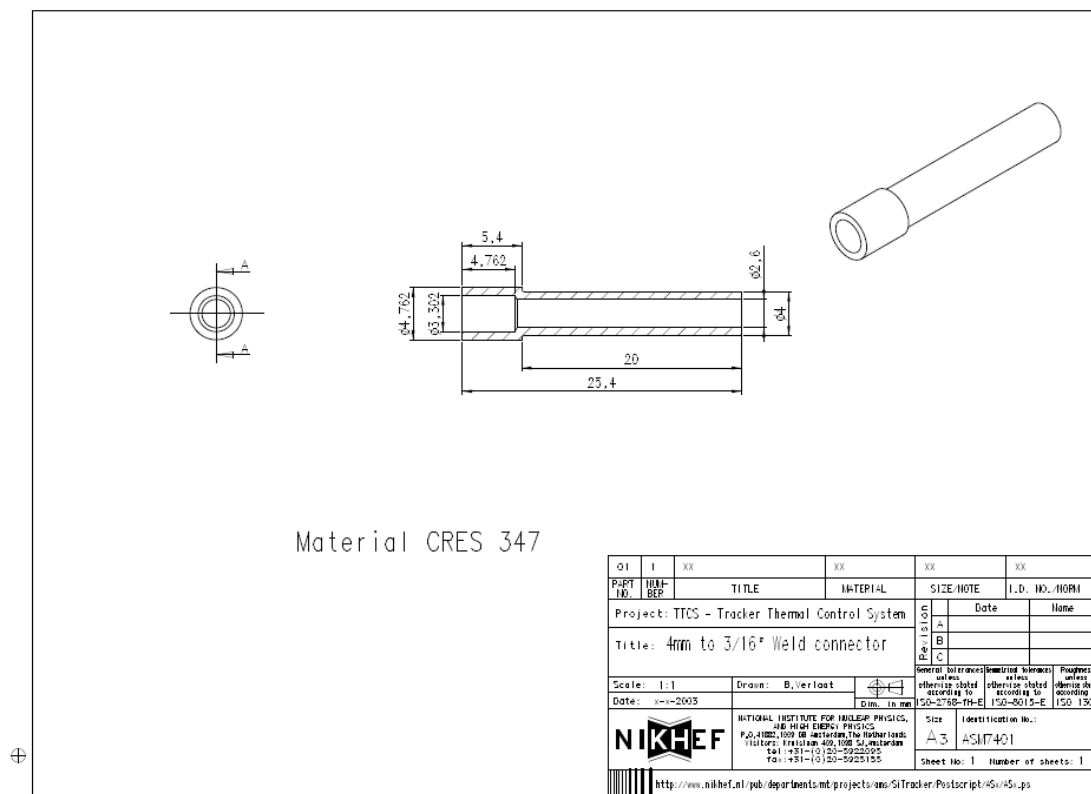
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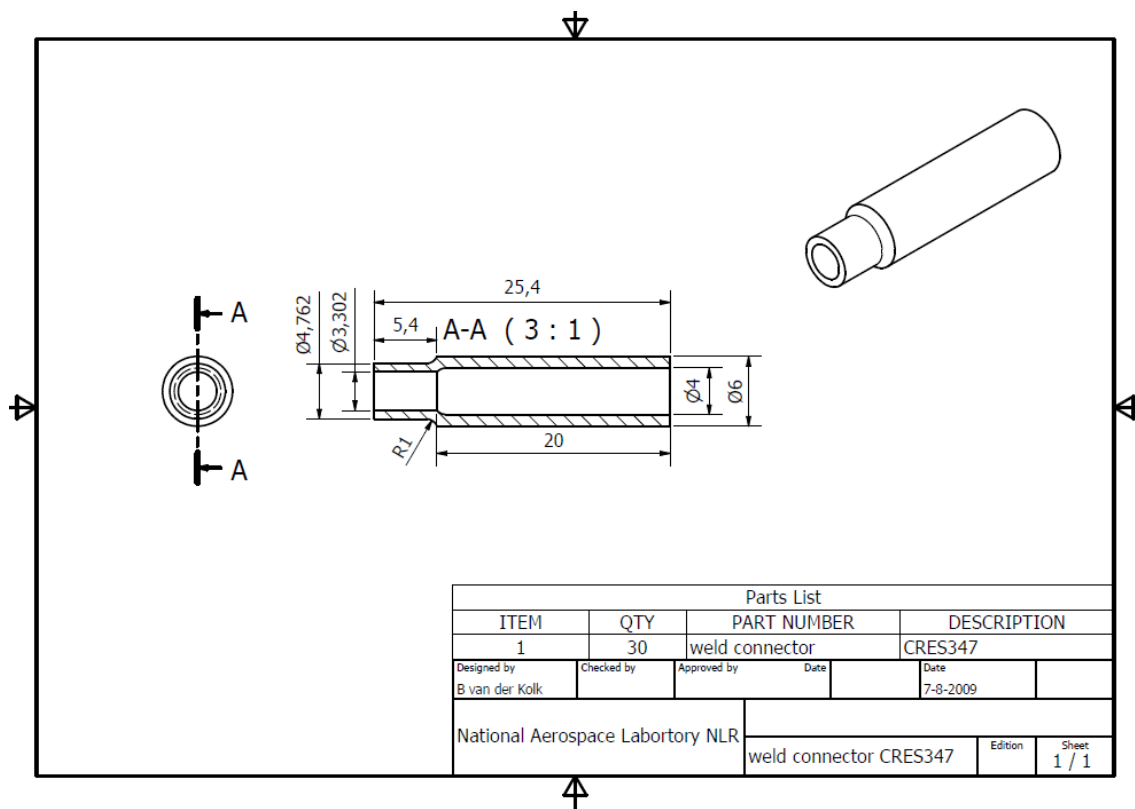
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## 10 Appendix A: Intermediate tube section to 316L $D_o = 4\text{mm}$ $D_i = 2.6\text{mm}$



Intermediate section to standard TTCS transport tube  $D_o = 4\text{mm}$   $D_i = 2.6\text{mm}$ .

## 11 Appendix B: Intermediate tube section to 316L $D_o = 6$ mm $D_i = 4$ mm



Intermediate section to standard TTCS transport tube  $D_o = 6$  mm  $D_i = 4$  mm.



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## 12 Appendix C: Tube and material certificates

**DOCKWEILER**

TUBE SYSTEMS IN STAINLESS STEEL

DOCKWEILER AG

An der Autobahn 10/20

DE-19306 Neustadt-Glewe

Dockweiler B.V.  
Krachtenveld 53

NL - 3893 CD Zeewoide  
NIEDERLANDE

Number of certificate pages: 1

### Certificate Advice Note

|                            |  |
|----------------------------|--|
| Your Order:                | 08187 / 52180C   |
| Your item:                 | 001  |
| Material:                  | Tube 6,00 x 1,00 1.4404<br>Ra <= 0,40µm / Ra(max.) <= 0,48µm |
| Quality:                   | TCC.1  |
| Quantity:                  | 53.91 m  |
| Dockweiler-no.:            | P46346   |
| Job-no.:                   | 06576031   |
| Job-no. of prematerial(s): | 05475481   |
| Heat(s):                   | 505204   |
| Our order no.:             | AUF07047688  |
| Our delivery note no.:     | LFS07067082  |
| Our delivery item no.:     | 001  |
| Delivered on:              | 2007-11-02   |

This document was created electronically and is valid without signature.

We herewith confirm that the product supplied is in conformity with the demands of the specification and agreements in the order.

Statement on QA system acc. to EN 784-5 (1/2003)

Certified by TÜV Nord on the basis of 97/23/EC, Annex 1, Section 4.3, Certificate No.: 07 202 3537 Z 0500054

Scope of application: T-piece checks on tubes of austenitic material (Diameter 17-170 mm, wall thickness 1.0-3.5 mm)

Date of expiry: 02/2008

Statement on welding procedures and welders' exams:

Approval of welding process by TÜV Nord, Cert. No. 072023037/000602/01-03, Test standard: 97/23/EC, AD2000 HP2/1, EN 288-3

Scope of application: Diameter 3-375 mm, wall thickness 0.7-3.05 mm

Welders' exams by TÜV Nord, Test standard: 97/23/EC, AD2000 HP3, EN287-1 and EN1418

pre-material certificate 3.1 is attached



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## FINE TUBES LIMITED

PLYMBRIDGE ROAD, ESTOVER, PLYMOUTH PL6 7LG  
Telephone: Plymouth +44 (0) 1752 735851  
Fax: +44 (0) 1752 733301  
Sales: +44 (0) 1752 697216



Test Certificate Number  
096422

|  |   |  |
|--|---|--|
| Customer Order No.<br><b>P46346/05003579*001</b> | Customer<br><b>DOCKWEILER AG<br/>AN DER AUTOBAHN 10/20<br/>19306 NEUSTADT-GLEWE<br/>GERMANY</b> | Material Designation<br><b>WERKSTOFF 1.4404 / 316L</b> |
| Fine Tubes Reference No.<br><b>206486</b>        |   | Form<br><b>DRAWN SEAMLESS TUBE</b>                     |
| Works Order No.<br><b>T206486*1</b>              |   | Temper<br><b>BRIGHTANNEALED 180HV(80HRB)MAX</b>        |
| Customer Part/Drawing                            | Dimensions<br><b>O.D. 6.0000 mm<br/>Wall 1.0000 mm</b>  | Quantity <b>1084.190 MTR</b>                           |
|  |   | Pieces <b>181</b>                                      |

### Specification

DOCKWEILER 2250 'DX' ULTRON BASE  
DIN 17458 ASTM A269/A213

### Chemical Analysis

Cast/Heat No. -505204

Melter **SANDVIK**  
Extruder **SANDVIK**

|     | C     | Mn   | P     | S      | Si      | Ni   | Cr    | Mo   | Ti    | Al    |
|-----|-------|------|-------|--------|---------|------|-------|------|-------|-------|
| %   | %     | %    | %     | %      | %       | %    | %     | %    | %     | %     |
| Top | 0.006 | 1.64 | 0.029 | 0.011  | 0.34    | 11.2 | 16.87 | 2.87 | 0.005 | 0.003 |
|     | Co    | Cu   | N2    | B      | Ca      |      |       |      |       |       |
| %   | %     | %    | %     | %      | %       |      |       |      |       |       |
| Top | 0.099 | 0.31 | 0.061 | 0.0009 | <0.0005 |      |       |      |       |       |

### Mechanical Properties

| Tensile     | 0.2% Proof | 1% Proof       | % Elongation | % Elongation | Hardness | Hardness HRS |
|-------------|------------|----------------|--------------|--------------|----------|--------------|
| Stress (Nm) | Stress     | Stress (Rp1.0) | 2"           | 5.65(0.5)    | HV/5.0   | Converted    |
| (MPa)       | (MPa)      | (MPa)          |              |              |          |              |
| 620         | 279        | 308            | 50           | 52           | 174-175  | 76.1-76.5    |
| 618         | 277        | 310            | 50           | 53           |          |              |

### Tests Performed And Accepted

|                            |                      |                          |              |
|----------------------------|----------------------|--------------------------|--------------|
| Intercrystalline Corrosion | Satisfactory         | I/D Surface Roughness Ra | 0.18 um      |
| Flattening                 | Satisfactory at 4 mm | Material Verification    | Satisfactory |
| Flare Test                 | Satisfactory at 8 mm | Eddy Current Test        | Satisfactory |
| O/D Surface Roughness Ra   | <0.8 um              | Visual Assessment        | Satisfactory |

### Additional Information

This material meets the chemical and mechanical property requirements of ASTM A269, ASTM A213 average wall, ASME SA213 average wall and DIN 17458 Test Class 1.  
Annealed at 1040 degrees C.  
Electric melted material.  
NACE MR 0175-2003.

### Declaration Information

Certified that, unless otherwise stated above, the whole of the Materials detailed hereon have been Manufactured, Tested and Inspected in accordance with the terms of the Contract/Order applicable thereto, and fully conform in all respects to the Standard Specifications and:  
BS EN 10204:2004 Type 3.1 / DIN EN 10204:2004 Type 3.1.  
in accordance with PED 97/23/EC Registration Number 04/202/2/430/0204027.

Dockweiler AG  
Job-Number:  
05475481  
Seite/Page 1/1  
Pers.-Nr. 210



FM 09729



EMS41528

Ian Olney

Quality Certification Representative

10/03/06

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NIKHEF batch (TTCB side)



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4 mm OD stainless steel box standard tubing



|   |  |   |   |  |  |
|---|--|---|---|--|--|
| <b>Abnahmeprüfzeugnis</b><br>Inspection Certificate   |  | <b>DIN</b><br>EN 10204 / 3.1 B  |   | <b>Zeugnis - Nr.</b> 23277                     |  |
| UTI-SFM Feinmechanik GmbH, Staatsstrasse 5, D-97773 Aura<br><br>Merinox B.V.<br>Postfach 23<br><br>NL-2950 Alblasserdam   |  | Kundenauftrag:<br>Your order: 20030089 vom 20.02.03<br><br>Unser Auftrag:<br>Our order: CF000680<br><br>Lieferbedingung:<br>Terms of Delivery: Lt. Auftragsbestätigung<br><br>Lieferzustand:<br>Delivery state: gegläht<br><br>Besondere Vereinbarungen:<br>Special terms:<br>Nahtlose Rohre gem. DIN 17458 Pk. 1, außer Punkt 5.3.2 und 6.3.1.6 (Verwechslungsprüfung) |   |  |  |
| Prüfgegenstand: Nichtrostende Rohre / Rohrformteile<br>Object: Stainless steel tubes / fittings<br><br>Werkstoff:<br>Material: 1.4404 nahtlos   |  |   |   |  |  |
| <b>Position</b><br>Item   | <b>Menge:</b><br>Quantity  | <b>Abmessung (mm)</b><br>size (mm)  | <b>Toleranzen</b><br>Tolerances   |  |  |
| 2   | 12,98 kg =<br>236 m  | 4,00 mm Ad. x<br>0,70 mm Wdd.   | D4<br>T3  |  |  |
| <b>Mechanische Werte / Mechanical Properties</b>  |  |   |   |  |  |
| <b>Position</b><br>Item   | <b>Zugfestigkeit</b><br>Tensile strength<br>Rm N/mm <sup>2</sup> | <b>Streckgrenze</b><br>Yield strength<br>Rp 0,2 N/mm <sup>2</sup>   | <b>Dehnung</b><br>Elongation<br>%   | <b>Härteprüfung</b><br>Hardness<br>Vickers 0,5 | <b>Dichtheitsprüf.</b><br>Leak proof test<br>bar |
| 1   | 668  | 319   | 56,96   |  |  |
| 2   | 632  | 373   | 65,07   |  |  |
| <b>Chemische Zusammensetzung des Einsatzmaterials</b><br>Chemical composition (according to works certificate of steel mill)  |  |   |   |  |  |
| <b>Schmelz - Nr.:</b> 453768<br><b>Cast No.:</b>  |  |   |   |  |  |
| <b>C %</b>  | <b>Si %</b>  | <b>Mn %</b>   | <b>P %</b>  | <b>S %</b>                                     | <b>Cr %</b>                                      |
| 0,018   | 0,390  | 1,700   | 0,032   | 0,008  | 17,01  |
| <b>Mo %</b>   | <b>Ni %</b>  | <b>Ti %</b>   | <b>Fe %</b>   | <b>Al %</b>                                    | <b>N %</b>                                       |
| 2,05  | 11,38  |   |   |  | 0,063  |
| <b>Cu %</b>   | 0,30   |   |   |  |  |
| <b>Ringaufdehnversuch:</b><br>Ring expansion test.  |  |   |   |  |  |
| <b>Kennzeichnung:</b><br>Marking:   |  |   |   |  |  |
| <b>Sicht- und Maßkontrolle:</b><br>Visual inspection and control of dimension: o.B.   |  |   |   |  |  |
| <b>Andere Prüfungen:</b><br>Other tests:  |  |   | <b>UTI-SFM Feinmechanik GmbH</b><br>Zertifiziert nach DIN EN ISO 9002: 1994<br>Qualitätsstelle<br><br>97773 Aura, 16.05.03<br><br>Abnahme:<br>Werksachverständige |  |  |
| Wir bestätigen, daß die oben aufgeführten Rohre den Lieferbedingungen entsprechend geprüft u. in Ordnung befunden wurden.<br>It is certified that the tubing listed as above has been tested in accordance with the terms of delivery and found satisfactory. |  |   |   |  |  |

VD-85-3 (QS) Änderung: d Elektronisch erstelltes Formular

NIKHEF batch (TTCB side)



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MicroGroup, Inc.  
7 Industrial Park Road  
Medway, MA 02053-1732  
Ph: 508-533-4925 / 1-800 ALL-TUBE  
Fx: 508-533-5691

MicroGroup  
www.microgroup.com

Customer: CERN  
Address 1: BUILDING 867  
Address 2: OFFICE R-H75  
City: CEDEX  
Prov/ST: -  
Zip/Postal Code: F-01631

Certification Group: 14820  
Certification: 14820  
Cust PO: Propay  
MG Order: MG00048124-1  
Cust Dwg/PN: Material Clean Footings  
MG Item: MAT-CLEAN-FT  
MG Job: C700006321-0  
Date: 03/26/2009  
Manufactured Lot: 946690  
Material Item: 316F10156X028SL  
Material Lot: R0000000002976  
Quantity: 260.00

## Certification of Compliance / Material

We hereby certify that all the items in the shipment have been produced, inspected and found to be in compliance with the applicable drawings, military specifications and/or standards, and purchase order requirements. All documents utilized were to the revision identified in the purchase order or as specified by the buyer. Substantiating records are on file subject to review upon request.

Where applicable, MicroGroup also certifies that the test numbers and analyses detailed herein are correct as contained in the records of this Corporation. Because the MicroGroup has no control over the subsequent processing of product application, the MicroGroup expressly disclaims any and all expressed or implied warranty other than the warranty herein set forth below. Such disclaimers include without limitation, warranty, or fitness for particular purpose and warranty of workmanship.

Authorized Signature: Mark S. Hindley  
Mark S. Hindley

Title: Quality Control Supervisor

## Physical Properties:

| Mat'l           | Grade  | Mfg Type | Category   | Gauge    | IPS      | Schedule  | L Grade   | Surf Cond |
|-----------------|--------|----------|------------|----------|----------|-----------|-----------|-----------|
| Stainless Steel | 316    | Seamless | Fractional |          |          |           | Yes       | Bright    |
| OD Max          | OD Min | ID Max   | ID Min     | Wall Max | Wall Min | OD Finish | ID Finish | Length:   |
| 0.1584          | 0.1580 |          |            | 0.0272   | 0.0268   |           |           |           |

## Chemical Properties:

| C%     | Mn%    | P%     | S%     | Si%    | Ni%     | Cr%     | Mo%    | Cu%    |
|--------|--------|--------|--------|--------|---------|---------|--------|--------|
| 0.0200 | 1.7200 | 0.0310 | 0.0030 | 0.3700 | 12.3000 | 16.5700 | 2.0700 | 0.1700 |
| Ti%    | Cb%    | Co%    | Al%    | N%     | Fe%     | Other%  | Other% | Hess#  |
| 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0082 |         |         |        | V00647 |

## Mechanical Properties:

| Temper      | Ultimate Tensile (PSI) | Yield Strength (PSI) | Hardness | Elongation % in 2" | Embrittlement | Eddy Curr | Bend       | Rev Bend |
|-------------|------------------------|----------------------|----------|--------------------|---------------|-----------|------------|----------|
| Annealed    | 78,000.00              | 31,900.00            |          | 53.00              |               | Y         |            |          |
| White Cloth | Flange                 | Flare                | Hydro Y  | Passivity          | Grain Size    | Micro     | Flattening |          |
|             |                        |                      |          |                    |               |           |            |          |

## Specifications:

| ASTM1   | ASTM2    | ASTM3 | AMS1 | AMS2 | AMS3 | MILIT1 | MILIT2 | MILIT3 |
|---------|----------|-------|------|------|------|--------|--------|--------|
| A269-98 | A213-99A |       |      |      |      |        |        |        |

## Additional Comments:

PARTS HAVE BEEN PICKLED  
PARTS HAVE BEEN RINSED WITH DIONIZED WATER

## Country of Origin:

Manufacturing:  
Melt Source:

Created By: parvanibkis

Microgroup batch (transport tubes side)



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## 13 Appendix D: Hydraulic Connector material certificates

### Parker Aerospace-Stratoflex Division MATERIAL CONTROL LABORATORY 2575 West 5th Street Jacksonville, FL 32254 Phone: (904) 389-3400

DATE 9/26/2007

P.O. 361

RECEIVER 0006834

HEAT TREAT

IBM NUMBER 1506802036

TEST REPORT/CERTIFICATION

MCL# PB 7270

HEAT G12673K10

SIZE/PART# 9/16" DIA

SPECIFICATION AMS 5659L (15CR-5NI)  
RES386

MATERIAL CODE

QUANTITY 48 IN.

The test report/certification supplied with raw material have been reviewed by Parker/Stratoflex Quality Control and meet the requirements of the above referenced specifications.

#### Additional Heat Numbers and Quantities

|                   |         |           |      |
|-------------------|---------|-----------|------|
| Receiver: 0006834 | Qty: 48 | Receiver: | Qty: |
| Receiver: 0014749 | Qty: 48 | Receiver: | Qty: |
| Receiver:         | Qty:    | Receiver: | Qty: |
| Receiver:         | Qty:    | Receiver: | Qty: |

#### TESTS PERFORMED

☒ Domestic Material

Hardness:

☐ STRATOFLEX

ROCKWELL:

☐ SUPPLIER

ROCKWELL:

Notes: WAS MCL PB 7255 THAN WAS HEAT TREATED PER RES 386.

#### PERIODIC CONTROL:

This material has undergone scheduled periodic control by an approved, independent laboratory IAW OP-08-05 and test results confirm compliance with the above referenced specification.

APPROVED FOR RELEASE ☒

I hereby certify that the above information is true.

EXHIBIT 3-FORM 33

MCL TECHNICIAN

Craig DeHaan





# AMS Tracker Thermal Control Subsystem

TTCB and condenser integration

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Braddock Metallurgical, Inc.-Jacksonville

## Certification

Order No.: 65282

Date: 05/07/2009

Entry Date: 04/10/2009

Page: 1 of 1

### To:

PARKER STRATOFLEX  
2575 WEST 5TH STREET

JACKSONVILLE FL 32254

Purchase Order No.: 05381

Packing List No.:

Material: 15-5 PH

We certify that the listed Parts / Material were treated as follows:

| Quantity | Part Number / Part Name / Part Description          | Pounds |
|----------|---|--------|
| 2        | RES 386 REV C<br>LOT 1506802036<br>9/16" RND. STOCK | 5      |

Total Order Quantity: 2  
Total Order Pounds: 5

AMS2759/3E RES 386 REV. C

| Insp. Type                    | Scale | Minimum | Maximum | Number | Other  |
|-------------------------------|-------|---------|---------|--------|--------|
| <b>Customer Requirements:</b> |       |         |         |        |        |
| Hardness                      | HRC   | 34.     | 37.     | .      | .      |
| Tensile                       | KSI   | 145.    | .       | .      | .      |
| Yield                         | KSI   | 125.    | .       | .      | .      |
| Elong                         | Pct.  | 13.     | .       | .      | .      |
| R. A.                         | Pct.  | 45.     | .       | .      | .      |
| <b>Results:</b>               |       |         |         |        |        |
| Hardness                      | HRC   | 34.     | 37.     |        | PASSED |
| Tensile                       | KSI   | 160.    |         |        | PASSED |
| Yield                         | KSI   | 156.    |         |        | PASSED |
| Elong                         | Pct.  | 18.     |         |        | PASSED |
| R. A.                         | Pct.  | 66.     |         |        | PASSED |

Pieces were aged to condition H1075 in furnace# 15 at 1075 F (+/-10F) for 246 minutes. Per AMS 2759/3E, RES 386 REV. C, and your purchase order.

ALL KSI VALUES HAVE BEEN CONVERTED TO HRC VALUES PER ASTM A 370.

Brandon L. Young  
Quality Assurance  
Braddock Metallurgical Co. Inc. of Jacksonville



44 PR3755



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Braddock Metallurgical, Inc.-Jacksonville Order No.: 54303

## Certification

Date: 09/25/2007

Entry Date: 09/24/2007

Page: 1 of 1

### To:

PARKER STRATOFLEX  
2575 WEST 5TH STREET

Purchase Order No.: 00361

Packing List No.:

JACKSONVILLE FL 32254

Material: 15-5 PH

We certify that the listed Parts / Material were treated as follows:

| Quantity | Part Number / Part Name / Part Description                 | Pounds |
|----------|--|--------|
| 1        | RES 386 REV C<br>LOT 1506802036<br>9/16" X 48" ROUND STOCK | 5      |

Total Order Quantity: 1  
Total Order Pounds: 5

AMS2759/3D RES 386 REV. C

| Insp. Type                    | Scale | Minimum | Maximum | Number | Other  |
|-------------------------------|-------|---------|---------|--------|--------|
| <b>Customer Requirements:</b> |       |         |         |        |        |
| Hardness                      | HRC   | 34.     | 37.     |        |        |
| <b>Results:</b>               |       |         |         |        |        |
| Hardness                      | HRC   | 34.5    | 34.5    | ✓      | PASSED |

Pieces were aged to condition H-1075 Per RES 386 REV C / AMS2759/3D in furnace#10 at 1075 F for 245 minutes.



PB7269

Quality Assurance  
Braddock Metallurgical Co. Inc. of Jacksonville



# AMS Tracker Thermal Control Subsystem

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## Parker Aerospace-Stratoflex Division

### MATERIAL CONTROL LABORATORY

2575 West 5th Street  
Jacksonville, FL 32254  
Phone: (904) 389-3400

DATE 9/13/2007

P.O. 3236

RECEIVER 0006637

HEAT TREAT

IBM NUMBER 1507602036

TEST REPORT/CERTIFICATION

MCL# PB 7255

HEAT G12673K10

SIZE/PART# 9/16"

SPECIFICATION AMS 5659L (15CR-5NL)

MATERIAL CODE

QUANTITY 144 IN.

The test report/certification supplied with raw material have been reviewed by Parker/Stratoflex Quality Control and meet the requirements of the above referenced specifications.

#### Additional Heat Numbers and Quantities

|           |      |           |      |
|-----------|------|-----------|------|
| Receiver: | Qty: | Receiver: | Qty: |
| Receiver: | Qty: | Receiver: | Qty: |
| Receiver: | Qty: | Receiver: | Qty: |
| Receiver: | Qty: |           |      |

#### TESTS PERFORMED

☒ Domestic Material

Hardness:

☐ STRATOFLEX

☐ SUPPLIER

ROCKWELL:

ROCKWELL:



Notes:

#### PERIODIC CONTROL:

This material has undergone scheduled periodic control by an approved, independent laboratory IAW OP-08-05 and test results confirm compliance with the above referenced specification.

APPROVED FOR RELEASE ☒

I hereby certify that the above information is true.

EXHIBIT 3-FORM 33

MCL TECHNICIAN

Ken Britt



# AMS Tracker Thermal Control Subsystem

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04-03-07 15:41 FROM-  
04/03/07 11:00 FAX 7163660478 DUNKIRK SPECIALTY STEEL



## Dunkirk Specialty Steel, LLC

A Universal Stainless & Alloy Products Company  
P.O. Box 319  
930 Brigham Rd.  
Dunkirk, NY 14048

ISO 9001:2000  
Registered Quality System

WILL ORDER: 0016758  
PART NUMBER: IAC 35141  
P.O. NUMBER: 01-13165

### Material Certification

P.O. DATE: 2/28/2006

PAGE NUMBER: 1 of 1  
PRINTED: 3/23/07 09:44

S A. M. CASTLE & CO.  
H 3400 N. WOLF ROAD  
I  
O  
P FRANKLIN PARK, IL 60131

Material Description: STAINLESS STEEL ROUND BAR 15-5 BAF+ADD+VAR SOLUTION ANNEALED CENTERLESS GROUND ASTM A564-04 (Type 1), XM-12 solution treated, Castle AMC 3155-01 Rev. 19, AMS 2300K (condition A), UNS# S15500, AMS 8659L (Type 1),

Size: .5625 DIAM X 132.0000 MIN/  
156.0000 MIN RANDOM LENGTH

| Heat Number | TOP | WT | C     | CR    | CO    | TA    | Q  | AL    | SI   | V    | SN    | TI    | CA | N     | P     | MO   | CB   | B | FE | SE | CR |
|-------------|-----|----|-------|-------|-------|-------|----|-------|------|------|-------|-------|----|-------|-------|------|------|---|----|----|----|
| 012673K10   |     |    | 0.046 | 14.42 | <0.05 | <0.01 |    | <0.01 | 0.54 | 0.09 | 0.007 | <0.01 |    | 0.020 | 0.002 | 0.27 | 0.32 |   |    |    |    |
|             |     |    | W     | CU    | AL    | MS    | NI |       |      |      |       |       |    |       |       |      |      |   |    |    |    |

HARDNESS: 363 BHN

H900 CAP: VTS/ KSI 205.8  
24Y/8 KSI 203.3  
REL 19.0  
R/A 58.0  
HARDNESS 404 BHN

MAGNETIC PARTICLE: F/S = 0/0

FERRITE: <2%

MICRO TEST: ACCEPTABLE

MACHO ETCH TEST: ACCEPTABLE  
THIS MATERIAL WAS SOLUTION TREATED AT A MINIMUM TEMPERATURE OF 1900°F FOR AN APPROPRIATE TIME FOLLOWED BY AIR COOLING

COUNTRY OF ORIGIN: USA

CASTLE METALS CORP.  
DATE RCVD 4/13/07  
IAC 35141  
APPROVED BY JW



/s/ Harry Gwronski

H.J. Gwronski, Manager Q.A.

03/23/07

Date

MELTED & MANUFACTURED IN COMPLIANCE WITH DFARS 252.225-7014 ALT 1. MELTED BY USAP IN BRIDGEVILLE, PA, USA  
Certification IAW DIN 50 049 / EN 10204 3.1B. The Test Results Shown Are Certified To Be A Correct Statement Of Records That Were  
Derived From Testing Samples Of The Material. Results Meet Applicable Specifications. No Welding Was Performed On The Material  
Supplied On This Order. Material Is Free From Mercury Contamination. Material Is Of NAFTA Origin.



# **AMS Tracker Thermal Control Subsystem**

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## **14 Appendix E: Intermediate CRES 347 material certificate**

To be scanned and copied



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## 15 Appendix F: Condenser manifolds material certificate 316L

**Rodacciai**

50

**COPIA CONFORME ALL'ORIGINALE**

**ATTESTATO DI CONTROLLO - Test Report** N. 03916/ 8 Data 14/05/08

Secondo According to . . . . . EN 10204:2004 2.2

**CLIENTE - Customer**

Il presente certificato è valido per:

CLIENTE **I.N.F.N. sez P5/clo PIP FISI04**

FABBRICA **1310** del **20/5/2008**

quantità **100.800**

**MERICAT SRL**  
LOC. SODI S. SABINA  
VIA A. PANZINI 12/18  
06132 ELLERA UMBRA PG

**ORDINE - Order** **D.d.T. - Delivery note**  
N. TEL Data 12/05/08 N. 03916/15 Data 14/05/08

**PESO** KG 8,0 **LUNGH. BARRE** 3.000 - 3.000

**QUALITA' - Grade**  
NORMA EN 10088-3:1995 X2CrNiMo17-12-2 WNr 1.4404 / 316L  
NORMA EN 10088-3:1995 X5CrNiMo17-12-2 WNr 1.4401

**Sigla RODACCIAI** . . . . . 316 PLUS

**COLATA - Heat** . . . . . 936195

**PROFILO - Shape** . . . . . TONDO

**DIMENSIONE - Size** . . . . . mm 20,00

**ESECUZIONE - Form of delivery** . . . . . SGR. RETT.

**ANALISI CHIMICA DI COLATA - Cast analysis**

| C     | Mn    | Si    | S     | P     | Cr     | Ni     | Mo    | Cu    | Co    |
|-------|-------|-------|-------|-------|--------|--------|-------|-------|-------|
| 0,024 | 1,660 | 0,390 | 0,025 | 0,033 | 16,600 | 10,150 | 2,000 | 0,290 | 0,160 |

N  
0,023

**CARATTERISTICHE MECCANICHE ALLO STATO DI FORNITURA**  
Mechanical properties of delivered material

|                        |                |       |
|------------------------|----------------|-------|
| Limite Elastico        | Rp (0,2) (MPa) | 597,8 |
| Carico di rottura      | Rm (MPa)       | 729,6 |
| Allungamento a rottura | A 5 (%)        | 31,6  |

Si attesta che il materiale della presente fornitura e' conforme alla prescrizione d'ordine e ad ogni altra specifica concordata contrattualmente con il cliente.  
Certificato generato da un sistema informatico secondo la norma EN 10204, valido senza firma.

Pag. 1 / 1

MERICAT srl  
Via A. Panzini 12/18  
06132 SANTA SABINA (Perugia)  
Tel. 075.5179441 - Fax 075.5179444  
C.F. e P. IVA 00163420540

MERICAT srl - Via A. Panzini 14/18 - 06132 Santa Sabina (Perugia) - Italy  
Tel. 075.5179441 r.a. - Fax 075.5179444 - www.mericat.it - e-mail: mericat@mericat.it  
Codice Fiscale, Partita I.V.A. e Registro Imprese 00163420540 - R.E.A. 96486/Pg - Capitale Sociale € 774.690,00



# AMS Tracker Thermal Control Subsystem

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## 16 Appendix G: Acceptance criteria for Class B pressure containing components

### SURFACE INSPECTION ACCEPTANCE CRITERIA - CLASS B - Pressure Containing Components

|  |  |
|--|--|
| Size and Appearance of Groove Welds        | Minimum size as specified on drawing. If profile requirements are not specified on the drawing, the weld shall be convex with a maximum reinforcement as stated herein. Any profile is unacceptable where the weld to base metal transition forms a sharp notch or reduces the base metal thickness (T) beyond the minimum specified on the drawing. |
| Size and Appearance of Fillet Welds        | Minimum size as specified on drawing. If profile requirements are not specified on the drawing, the weld shall be flat or slightly convex with a maximum reinforcement as stated herein. Any profile is unacceptable where the weld to base metal transition forms a sharp notch or reduces (T) beyond the minimum specified on the drawing.         |
| Cracks                                     | None allowed.  |
| Undercut                                   | Undercut shall not exceed 15% of the total weld length. The depth of any undercut indication where $T < 0.035"$ , undercut shall not exceed 10% of T. Where T is $\geq 0.035"$ and $\leq 0.09"$ , undercut shall not exceed 15% of T or 0.010", whichever is the lesser. Where $T > 0.09"$ , the depth of undercut shall not exceed 0.015".          |
| Pores or Voids                             | The maximum diameter shall not exceed 0.02" or 1/3 of T, whichever is the lesser. Indications less than .010" in diameter shall not be considered.   |
| Weld Face or Root Concavity or WM Thinning | Concavity shall not exceed 15% of T or 0.015", whichever is the lesser.  |
| Overlap                                    | None allowed.  |
| Misalignment                               | Misalignment shall not exceed 15% of T or 0.025", whichever is the lesser.   |
| Peaking                                    | Weld joint peaking shall not exceed a total of 5 degrees.  |
| Weld Face or Root Convexity                | Reinforcement, or melt-thru, shall not exceed 20% T or 0.06", whichever is the lesser.   |
| Surface Discoloration                      | A black - brown color is not allowed.  |
| Surface Roughness                          | Surface finish of welds and adjacent material resulting from processes used to remove weld reinforcement and otherwise shall not exceed 63 microinches.  |
| General Workmanship                        | Weld deposits, face and root reinforcement and adjacent base metal shall display a smooth and uniform appearance. The weld toes shall blend smoothly into the base metal without unfused overlaps or undercut exceeding that specified.  |



# AMS Tracker Thermal Control Subsystem

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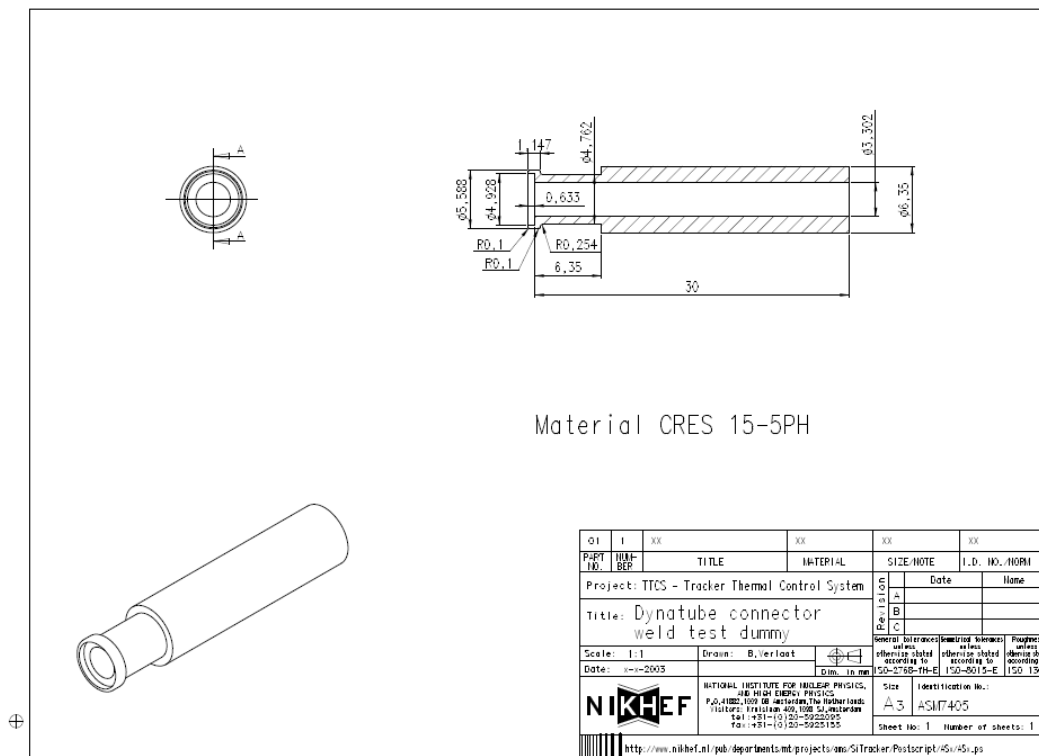
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## 17 Appendix H: Weld sample drawings connector dummies



For the weld qualification of the intermediate material the samples are exact copies of the flight parts as shown in Appendix A and B.



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## 18 Appendix I: Weld sample drawing transport tubes

| DWG NO. 87-52-0001 |             | SH 01     | REV --   |
|--------------------|-------------|-----------|----------|
| REVISION HISTORY   |             |           |          |
| REV                | DESCRIPTION | DATE      | APPROVED |
|                    |             | 4/12/2007 |          |

| PART NO. | Dia. A | Dia. B |
|----------|--------|--------|
| -101     | 6      | 4      |
| -102     | 4      | 2.4    |

| UNLESS OTHERWISE SPECIFIED<br>DIMENSIONS ARE IN MM |         |
|--|---------|
| LINEAR TOLERANCES                                  | -       |
| ANGULAR TOLERANCES                                 | ±0° 30' |
| ALL MACHINED SURFACE                               | 3.2     |
| THIRD ANGLE PROJECTION                             |         |

|   |            |                           |   |
|---|------------|---------------------------|---|
| DRAWN BY  | 12/04/2007 |                           | Aerospace Industrial<br>Development Corporation<br>Taichung, Taiwan, R.O.C. |
| C.C. YEH  |            |                           |   |
| DESIGNER  | 12/04/2007 |                           |   |
| C.C. YEH  |            | DRAWING TITLE             |   |
| DESIGN APP  | 12/04/2007 | ORBITAL WELDING TEST TUBE |   |
| SEE PL. SHEET FOR PARTS LIST AND<br>SPECIFIC NOTES<br>SEE DRAWING CONTROL CARD FOR<br>REVIEW RECORD |            | SIZE                      | CAGE CODE   |
|   |            | B                         | S7549   |
|   |            | DWG NO.                   | 87-52-0001  |
|   |            | REV                       | --  |
|   |            | SCALE                     | 1/1   |
|   |            | SHEET 01 OF 01            |   |

FRM-CR-172



# AMS Tracker Thermal Control Subsystem

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## 19 Appendix J: Burst test requirements TTCB weld sample tubes

For the structural verification a burst test need to be performed. The following is copied from the AMS structural verification requirements document:

B1: Where “MDP” stands for “Maximum Design Pressure”. MDP for a pressurized system shall be the highest pressure defined by the maximum relief pressure, maximum regulator pressure **or maximum temperature.**

B2: The “Ultimate pressure factor” is a multiplying factor applied to the MDP to obtain ultimate pressure. Pressurized components are to be designed to the following factors of safety.

### Table:

| Lines and fittings:             | Burst             | Proof             |
|---------------------------------|-------------------|-------------------|
| <b><i>Diameter &lt;1.5”</i></b> | <b><i>4.0</i></b> | <b><i>1.5</i></b> |
| <i>Diameter =&gt;1.5”</i>       | 2.5               | 1.5               |
| <i>Other components</i>         | 2.5               | 1.5               |

For the TTCB burst sample test it follows that the burst test need to be performed for 4 \* MDP. The MDP for TTCS = 160 bar meaning the burst pressure will be 640 bar for the tubing.

The burst test can be performed with a Swagelok coupling (with stainless ferrule) closing on one side of the weld sample and a connecting coupling (with stainless ferrule) on the other side to apply the pressure.

Figures of the configurations are shown on the next page.

**Pay attention to personal safety aspects and perform the test such that no connector can be bulleted around the area.**

For the weld-coupling to weld coupling type of welds, weld additional tube to the connectors to be able to perform the burst test. Drawback is that 3 welds need to perfect but this is the most straight forward way to perform the test.

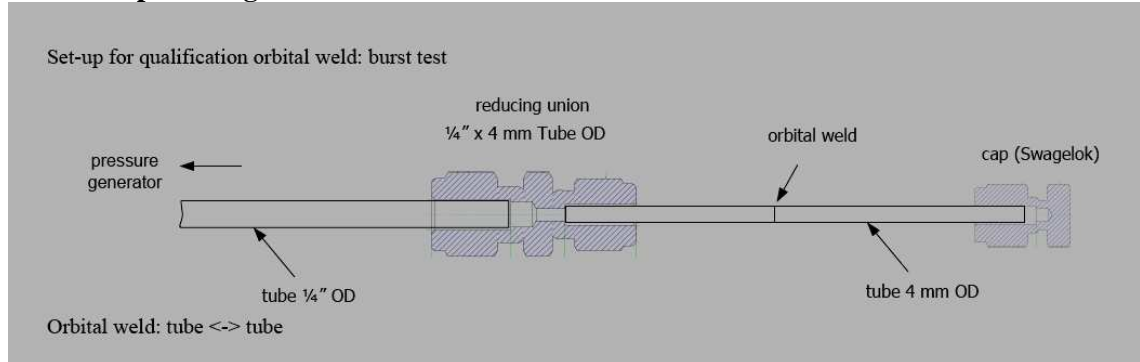
### Acceptance criteria

1. He-leak tightness before burst  $<1 \cdot 10^{-9}$  mbarl/s (or  $0,9708 \cdot 10^{-9}$  atm cc /s)
2. The burst sample shall withstand the burst pressure

### Documentation

1. Document pressures
2. The burst sample deformation shall be visually inspected and documented (photographed)

## Burst sample configurations



**Figuur 19-1: Type tube-tube weld**



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## 20 Appendix K: PQR

### YOUR COMPANY/ORG name goes here ORBITAL TUBE GAS TUNGSTEN ARC WELDING PROCEDURE QUALIFICATION RECORD (PQR)

Page 1 of 2

PQR Number \_\_\_\_\_ Revision \_\_\_\_\_ Company / Organization \_\_\_\_\_  
Supporting WPS no.(s) \_\_\_\_\_ Welding Process(es) Automatic Orbital Tube Gas Tungsten Arc

#### BASE and FILLER METAL :

Material number \_\_\_\_\_ Group \_\_\_\_\_ to Material number \_\_\_\_\_ Group \_\_\_\_\_  
Material spec., type, and grade \_\_\_\_\_ to Material spec., type, & grade \_\_\_\_\_  
Base metal thickness range \_\_\_\_\_  
Pipe / Tube diameter \_\_\_\_\_ Wall thickness \_\_\_\_\_  
Filler metal F No. \_\_\_\_\_ AWS Class & Spec. \_\_\_\_\_  
Consumable Insert, AWS Class & Spec. \_\_\_\_\_

#### GAS :

Torch gas(es) \_\_\_\_\_  
% Composition \_\_\_\_\_ Flow Rate \_\_\_\_\_  
Prepurge Time \_\_\_\_\_ Postpurge Time \_\_\_\_\_  
Backing gas(es) \_\_\_\_\_  
% Composition \_\_\_\_\_ Flow rate \_\_\_\_\_  
Prepurge Time \_\_\_\_\_ Postpurge Time \_\_\_\_\_

#### WELDING SET-UP :

Power Supply (Model) \_\_\_\_\_  
Weld Head(s) \_\_\_\_\_  
Joint Position(s) \_\_\_\_\_  
Tungsten type \_\_\_\_\_ Diameter \_\_\_\_\_ Arc gap \_\_\_\_\_  
Tip diameter \_\_\_\_\_ Tip angle \_\_\_\_\_  
Weld direction \_\_\_\_\_ Pulse Mode \_\_\_\_\_

#### PRE and POSTWELD HEAT :

Preheat temperature minimum \_\_\_\_\_  
Preheat temperature maximum \_\_\_\_\_  
Interpass temperature minimum \_\_\_\_\_  
Interpass temperature maximum \_\_\_\_\_  
Postweld Heat Treatment \_\_\_\_\_

#### WELD SETTINGS :

Start current (amps) \_\_\_\_\_ Upslope (sec.) \_\_\_\_\_  
Level Slope Time (sec.) \_\_\_\_\_ Downslope (sec.) \_\_\_\_\_  
Start Delay (sec.) \_\_\_\_\_ Override (%) \_\_\_\_\_  
Finish Current (amp) \_\_\_\_\_ Fixture Speed (RPM) \_\_\_\_\_  
Weld Timer (on/off) \_\_\_\_\_ Step Mode (on/off) \_\_\_\_\_  
Wire Mode (on/off) \_\_\_\_\_ Finish Current \_\_\_\_\_

#### JOINT DESIGN :

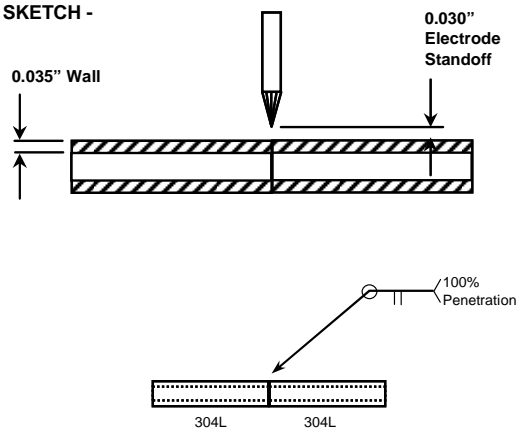
Joint type \_\_\_\_\_  
Groove angle \_\_\_\_\_ Radius \_\_\_\_\_ Land \_\_\_\_\_  
Root opening \_\_\_\_\_ Size of fillet \_\_\_\_\_  
Socket weld pull-back \_\_\_\_\_

#### NOMINAL HEAT INPUT CONDITIONS :

| Level Number | Weld Time (sec.) | Allowable Current (amps) Settings |         |       |         | Pulse Rate (pps) | Pulse Width Nominal |
|--------------|------------------|-----------------------------------|---------|-------|---------|------------------|---------------------|
|              |                  | +5%                               | Nominal | -5%   | Nominal |                  |                     |
| _____        | _____            | _____                             | _____   | _____ | _____   | _____            | _____               |
| _____        | _____            | _____                             | _____   | _____ | _____   | _____            | _____               |
| _____        | _____            | _____                             | _____   | _____ | _____   | _____            | _____               |
| _____        | _____            | _____                             | _____   | _____ | _____   | _____            | _____               |

#### TECHNIQUE :

#### SKETCH -



We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of the NASA / JSC PRC-0010.

Qualifier : \_\_\_\_\_ Reviewed by : \_\_\_\_\_

Date : \_\_\_\_\_ Approved by : \_\_\_\_\_



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## PROCEDURE QUALIFICATION RECORD ( PQR ) for Page 2 of 2 ORBITAL TUBE GAS TUNGSTEN ARC WELDING

PQR No. \_\_\_\_\_

### TENSILE TEST SPECIMENS :

Type : \_\_\_\_\_ Tensile specimen size : \_\_\_\_\_ Area: \_\_\_\_\_

Groove ( ) Socket Lap w/fillet ( )

Tensile test results : (minimum required UTS : \_\_\_\_\_ psi)

| Specimen No. | O.D., in. <sup>(a)</sup> | Wall Thkns, in. | Area, in <sup>2</sup> | Max Load, lbs | F <sub>tu</sub> , psi | Type Failure/Loc |
|--------------|--------------------------|-----------------|-----------------------|---------------|-----------------------|------------------|
|--------------|--------------------------|-----------------|-----------------------|---------------|-----------------------|------------------|

### GUIDED BEND TEST SPECIMENS - SPECIMEN SIZE: \_\_\_\_\_

| Type | Result | Type | Result |
|------|--------|------|--------|
|------|--------|------|--------|

### MACRO - EXAMINATION RESULTS :

### IMPACT TEST SPECIMENS

Type : \_\_\_\_\_ Size : \_\_\_\_\_

Test temperature : \_\_\_\_\_

Specimen location : WM = weld metal; BM = base metal; HAZ = heat - affected zone

| Test results :<br>Welding position | Specimen location | Energy absorbed<br>( ft. - lbs. ) | Ductile fracture area ( percent ) | Lateral expansion<br>( mils ) |
|------------------------------------|-------------------|-----------------------------------|-----------------------------------|-------------------------------|
|------------------------------------|-------------------|-----------------------------------|-----------------------------------|-------------------------------|

### IF APPLICABLE

### RESULTS

|   |                |                  |
|---|----------------|------------------|
| Hardness tests : ( ) Values _____               | Acceptable ( ) | Unacceptable ( ) |
| Visual Inspection ( ) _____                     | Acceptable ( ) | Unacceptable ( ) |
| Torque ( ) psi _____                            | Acceptable ( ) | Unacceptable ( ) |
| Proof test ( ) Method _____                     | Acceptable ( ) | Unacceptable ( ) |
| Chemical analysis ( ) _____                     | Acceptable ( ) | Unacceptable ( ) |
| Non-destructive exam ( ) Process _____          | Acceptable ( ) | Unacceptable ( ) |
| Other _____                                     | Acceptable ( ) | Unacceptable ( ) |
| Mechanical testing conducted by (Company) _____ | Lab No. _____  |                  |

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of the NASA / JSC PRC-0010.

Qualifier : \_\_\_\_\_ Reviewed by : \_\_\_\_\_

Date : \_\_\_\_\_ Approved by : \_\_\_\_\_



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## 21 Appendix L: WPS

**YOUR COMPANY/ORGANIZATION NAME goes here**

### ORBITAL TUBE ARC WELDING PROCEDURE SPECIFICATION (WPS)

WPS Number \_\_\_\_\_ Revision \_\_\_\_\_ Company / Organization \_\_\_\_\_  
Supporting PQR no.(s) \_\_\_\_\_ Welding Process(es) Automatic Orbital Tube Gas Tungsten Arc

#### BASE and FILLER METAL :

Material number \_\_\_\_\_ Group \_\_\_\_\_ to Material number \_\_\_\_\_ Group \_\_\_\_\_  
Material spec., type, and grade \_\_\_\_\_ to Material spec., type, & grade \_\_\_\_\_  
Base metal thickness range \_\_\_\_\_  
Pipe / Tube diameter \_\_\_\_\_ Wall thickness \_\_\_\_\_  
Filler metal F No. \_\_\_\_\_ AWS Class & Spec. \_\_\_\_\_  
Consumable Insert, AWS Class & Spec \_\_\_\_\_

#### WELDING SET-UP :

Power Supply (Model) \_\_\_\_\_  
Weld Head(s) \_\_\_\_\_  
Joint Position(s) \_\_\_\_\_  
Tungsten type \_\_\_\_\_ Diameter \_\_\_\_\_ Arc gap \_\_\_\_\_  
Tip diameter \_\_\_\_\_ Tip angle \_\_\_\_\_  
Weld direction \_\_\_\_\_ Pulse Mode \_\_\_\_\_

#### WELD SETTINGS :

Start current (amps) \_\_\_\_\_ Upslope (sec.) \_\_\_\_\_  
Level Slope Time (sec.) \_\_\_\_\_ Downslope (sec.) \_\_\_\_\_  
Start Delay (sec.) \_\_\_\_\_ Override (%) \_\_\_\_\_  
Finish Current (amp) \_\_\_\_\_ Fixture Speed (RPM) \_\_\_\_\_  
Weld Timer (on/off) \_\_\_\_\_ Step Mode (on/off) \_\_\_\_\_  
Wire Mode (on/off) \_\_\_\_\_

#### NOMINAL HEAT INPUT CONDITIONS :

| Level<br>Number | Weld<br>Time<br>(sec.) | Allowable Current (amps) Settings |                 |       |                | Pulse<br>Rate<br>(pps) | Pulse<br>Width<br>Nominal |
|-----------------|------------------------|-----------------------------------|-----------------|-------|----------------|------------------------|---------------------------|
|                 |                        | +5%                               | HIGH<br>Nominal | -5%   | LOW<br>Nominal |                        |                           |
| 1               | _____                  | _____                             | _____           | _____ | _____          | _____                  | _____                     |
| 2               | _____                  | _____                             | _____           | _____ | _____          | _____                  | _____                     |
| 3               | _____                  | _____                             | _____           | _____ | _____          | _____                  | _____                     |
| 4               | _____                  | _____                             | _____           | _____ | _____          | _____                  | _____                     |

#### TECHNIQUE :

Joint cleaning \_\_\_\_\_  
Other \_\_\_\_\_

#### GAS :

Torch/Head gas(es) \_\_\_\_\_  
% Composition \_\_\_\_\_ Flow Rate \_\_\_\_\_  
Prepurge Time \_\_\_\_\_ Postpurge Time \_\_\_\_\_  
Backing gas(es) \_\_\_\_\_  
% Composition \_\_\_\_\_ Flow rate \_\_\_\_\_  
Prepurge Time \_\_\_\_\_ Postpurge Time \_\_\_\_\_

#### PRE and POSTWELD HEAT :

Preheat temperature minimum \_\_\_\_\_  
Preheat temperature maximum \_\_\_\_\_  
Interpass temperature minimum \_\_\_\_\_  
Interpass temperature maximum \_\_\_\_\_  
Postweld Heat Treatment \_\_\_\_\_

#### JOINT DESIGN :

Joint type \_\_\_\_\_  
Groove angle \_\_\_\_\_ Radius \_\_\_\_\_ Land \_\_\_\_\_  
Root opening \_\_\_\_\_ Size of fillet \_\_\_\_\_  
Socket weld pull-back \_\_\_\_\_

#### SETUP SKETCH -

We certify that this welding procedure and schedule were qualified in accordance with the requirements of NASA / JSC PRC-0010.

Prepared By \_\_\_\_\_ Org. \_\_\_\_\_ Date \_\_\_\_\_

Approved By \_\_\_\_\_ Org. \_\_\_\_\_ Date \_\_\_\_\_



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## 22 Appendix M: Swagelok Micro-weld head series 4

[www.swagelok.com](http://www.swagelok.com)

### Orbital Welding System Micro Weld Heads



#### Series 4 and Series 8

- Available for tube outside diameters ranging from 1/16 to 1/2 in. and 2 to 12 mm
- Features a compact size for easy access to confined welding areas
- Weld head includes arc gap gauge, centering gauge, micro fixture tool, tool package, and tungsten electrodes

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## 2 Orbital Welding System—Series 4 and Series 8

### Features

- Miniature design permits access to confined welding areas
- Optical speed control—no tachometer or calibration required
- Improved productivity from the ability to set up one fixture while welding with another fixture

### Series 4

- For weld joint outside diameters of 1/16 to 1/4 in. and 2 to 6 mm
- Rigid- or flexible-drive weld head for ultimate versatility

### Series 8

- For weld joint outside diameters of 1/8 to 1/2 in. and 3 to 12 mm

### Technical Data

| Weld Joint Nominal Outside Diameter | Weld Head Series | Minimum Axial Clearance in. (mm) | Minimum Radial Clearance in. (mm) | Maximum Average Weld Current | Maximum Welds per Hour |
|-------------------------------------|------------------|----------------------------------|-----------------------------------|------------------------------|------------------------|
| 1/16 to 1/4 in.;<br>2 to 6 mm       | 4                | 0.490 (12.4)                     | 0.84 (21.3)                       | 30 A                         | 10 to 12 <sup>①</sup>  |
| 1/8 to 1/2 in.;<br>3 to 12 mm       | 8                |                                  | 1.00 (25.4)                       | 38 A                         | 12 <sup>②</sup>        |

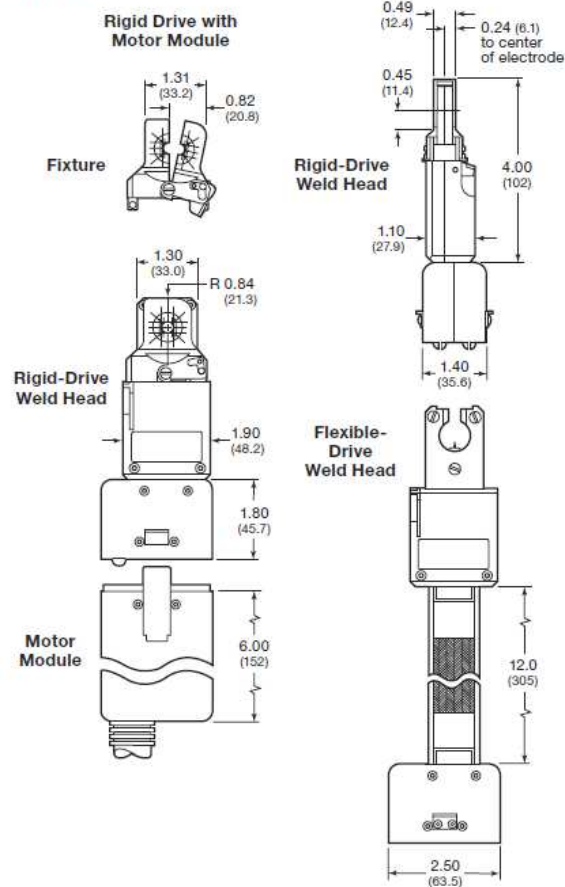
① Based on welding 1/4 × 0.035 in. 316L tubing.

② Based on welding 1/2 × 0.049 in. 316L tubing.

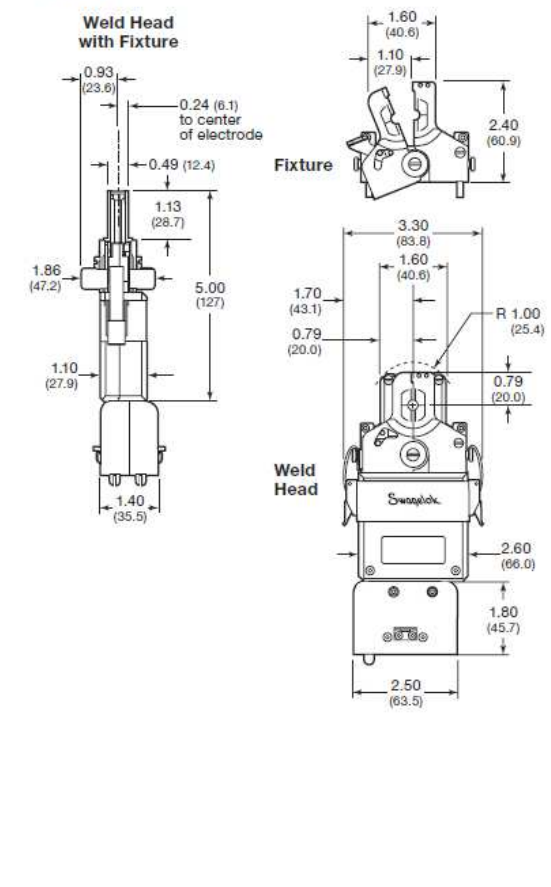
### Dimensions

Dimensions, in inches (millimeters), are for reference only and are subject to change.

#### Series 4



#### Series 8



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## Ordering Information

Swagelok® Series 4 and Series 8 micro weld heads are shipped with an arc gap gauge, centering gauge, tool package, fixture tool, assorted electrode packages, and user's manual.

## Micro Weld Heads

| Series | Weld Head Drive | Ordering Number |
|--------|-----------------|-----------------|
| 4      | Rigid           | SWS-4MRH-B      |
|        | Flexible        | SWS-4MFH-B      |
| 8      | Rigid           | SWS-8MRH-B      |



## Motor Modules

- Only one motor module is necessary to operate either series weld head model.
- Has polarized power connectors to ensure proper weld head/power supply connections

| Description  | Ordering Number |
|--------------|-----------------|
| Motor module | SWS-M-MTR-B     |



## Micro Weld Head Fixtures

- Front-load scissor action provides access to confined areas for close-coupled welding
- Cantilever design fixture collets compensate for tube outside diameter variations of  $\pm 0.005$  in. (0.13 mm)
- Laser-inscription on the fixtures assists user with parts orientation
- Split-base design provides component alignment adjustment



| Weld Joint Nominal Outside Diameter<br>in. | Ordering Number |
|--|-----------------|
| <b>Series 4 Weld Head</b>                  |                 |
| 1/16                                       | SWS-4MFB-01     |
| 1/8  | SWS-4MFB-02     |
| 3/16                                       | SWS-4MFB-03     |
| 1/4  | SWS-4MFB-04     |
| <b>Series 8 Weld Head</b>                  |                 |
| 1/8  | SWS-8MFA-02     |
| 1/4  | SWS-8MFA-04     |
| 3/8  | SWS-8MFA-06     |
| 1/2  | SWS-8MFA-08     |

| Weld Joint Nominal Outside Diameter<br>mm | Ordering Number |
|---|-----------------|
| <b>Series 4 Weld Head</b>                 |                 |
| 2   | SWS-4MFB-2MM    |
| 3   | SWS-4MFB-3MM    |
| 4   | SWS-4MFB-4MM    |
| 6   | SWS-4MFB-6MM    |
| <b>Series 8 Weld Head</b>                 |                 |
| 5   | SWS-8MFA-5MM    |
| 6   | SWS-8MFA-6MM    |
| 8   | SWS-8MFA-8MM    |
| 9   | SWS-8MFA-9MM    |
| 10  | SWS-8MFA-10MM   |
| 11  | SWS-8MFA-11MM   |
| 12  | SWS-8MFA-12MM   |

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## Accessories

### Arc Gap Gauges

Swagelok arc gap gauges position the electrode precisely in the rotor for repeatable welds. The easy-to-use gauge helps eliminate errors associated with sight and feeler gauge adjustments. One arc gap gauge comes with the weld head.



| Series | Ordering Number |
|--------|-----------------|
| 4      | CWS-4MAG        |
| 8      | CWS-8MAG        |

### Centering Gauges

The micro weld head centering gauge ensures accurate centering of weld components in the micro fixture. One centering gauge comes with the weld head.



| Series | Ordering Number |
|--------|-----------------|
| 4      | CWS-4MCG        |
| 8      | CWS-8MCG        |

### Micro Fixture Tool

This tool engages the fixture latch for easy opening and closing of the micro weld head fixture. One micro fixture tool comes with the weld head.



| Description        | Ordering Number |
|--------------------|-----------------|
| Micro fixture tool | CWS-MFP-FIXTL   |

### Cooling Plates

Swagelok cooling plates quickly absorb heat away from the micro weld head fixture and components after welding.



| Series | Ordering Number |
|--------|-----------------|
| 4      | CWS-4MCP        |
| 8      | CWS-8MCP        |

### Bench Mounting Brackets

Swagelok bench mounting brackets attach rigid- or flexible-micro weld heads to a work bench. The Series 4 bracket features a quick-release mechanism for convenient operation.



| Series | Ordering Number |
|--------|-----------------|
| 4      | CWS-4MBB        |
| 8      | CWS-8MBB        |

### Weld Head Extension Cables

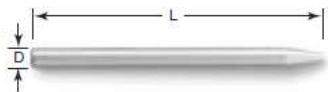
Swagelok weld head extension cables, in combination with the standard motor module, provide weld head operation of up to 50 ft (15.2 m) away from the power supply. Cables are available in lengths of 12.5 and 37.5 ft (3.8 and 11.4 m).



| Extension Cable, ft (m) | Ordering Number   |
|-------------------------|-------------------|
| 12.5 (3.8)              | SWS-WHEC-B-12.5FT |
| 37.5 (11.4)             | SWS-WHEC-B-37.5FT |

### Tungsten Electrodes

Swagelok electrodes, available in packages of ten, provide consistent, repeatable welds. Electrodes consist of 2 % ceriated tungsten, axially ground to rigid specifications.



| Weld Joint Nominal Outside Diameter | Electrode Diameter (D) | Electrode Length (L) | Ordering Number  |
|-------------------------------------|------------------------|----------------------|------------------|
| in.                                 | mm                     | in. (mm)             |                  |
| <b>Series 4 Weld Head</b>           |                        |                      |                  |
| 1/16, 1/8, 3/16                     | 2, 3, 4                | 0.040 (1.0)          | CWS-C.040-.405-P |
| 1/4                                 | 6                      | 0.325 (8.26)         | CWS-C.040-.325-P |
| <b>Series 8 Weld Head</b>           |                        |                      |                  |
| 1/8                                 | 3, 5                   | 0.450 (11.4)         | CWS-C.040-.450-P |
| 1/4                                 | 6, 8, 9                | 0.405 (10.3)         | CWS-C.040-.405-P |
| 3/8                                 | 10, 11                 | 0.325 (8.26)         | CWS-C.040-.325-P |
| 1/2                                 | 12                     | 0.281 (7.14)         | CWS-C.040-.281-P |

### Safe Product Selection

When selecting a product, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

**Caution: Do not mix or interchange parts with those of other manufacturers.**

### Warranty Information

Swagelok products are backed by The Swagelok Limited Lifetime Warranty. For a copy, visit [swagelok.com](http://swagelok.com) or contact your authorized Swagelok representative.

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